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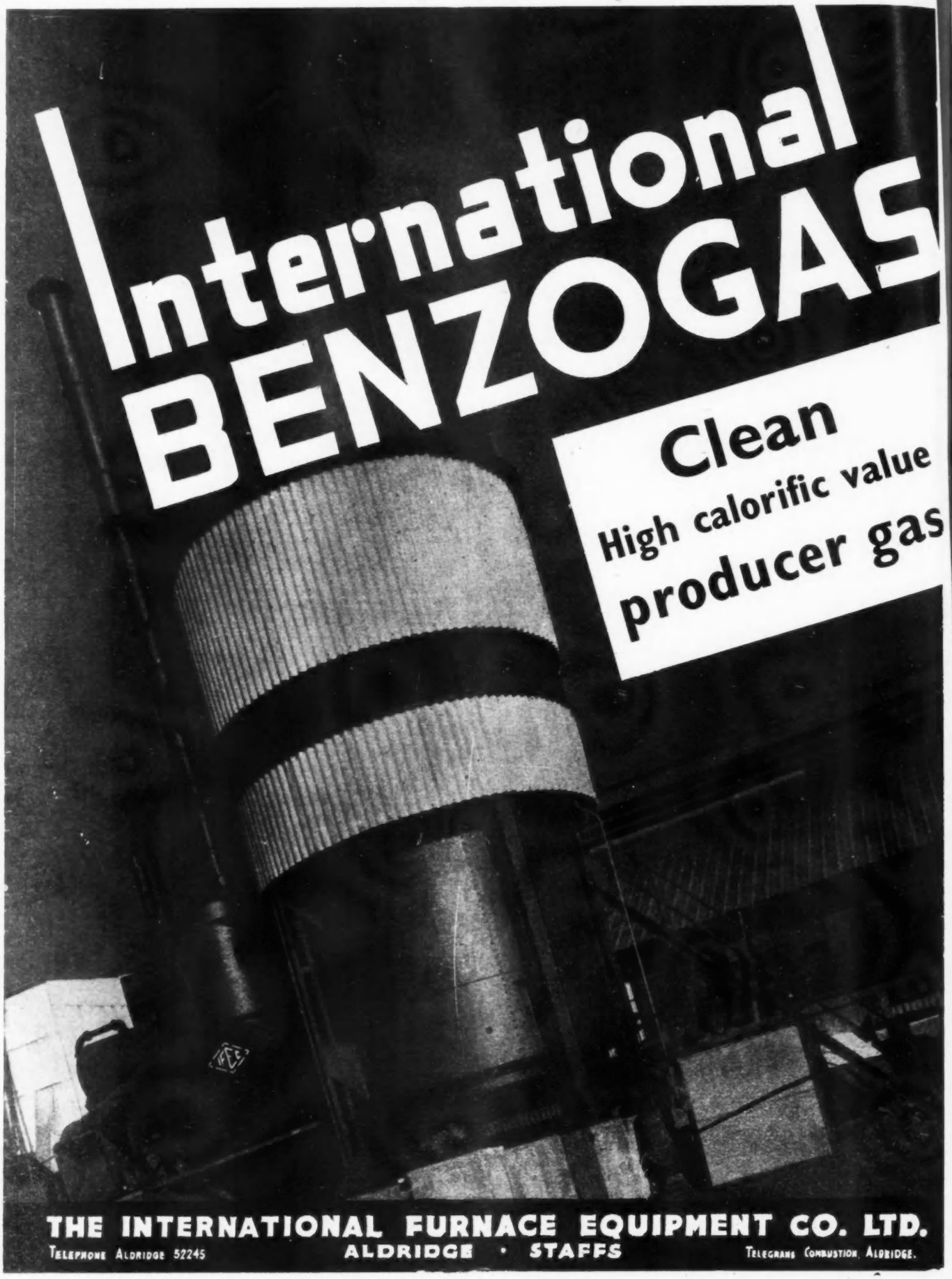
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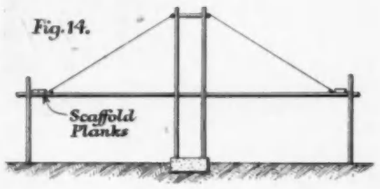
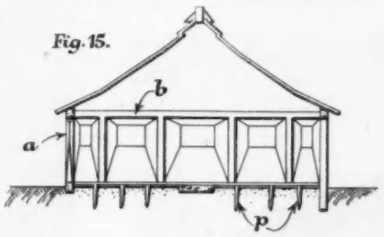
DEVELOPMENTS IN CONCRETE-CONSTRUCTION METHODS.

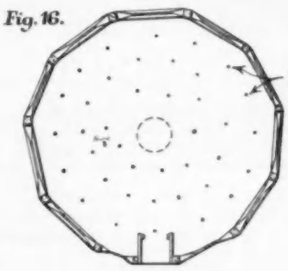
By ROLT HAMMOND, A.C.G.I., Assoc.M.Inst.C.E.

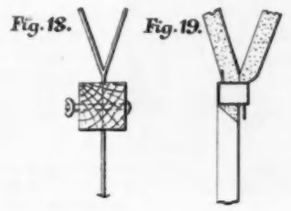
(*Concluded from page* 482.)

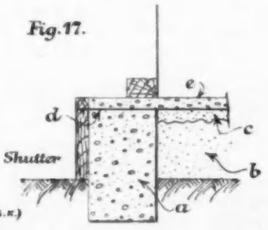
A NOVEL constructional method, embodying several interesting features, is due to Major J. H. de W. Waller, M.Inst.C.E. This makes use of the simple application of cement and sand rendering on a jute fabric. The application of the method to a circular hut is illustrated in Figs. 14 to 19 on this page. A series of steel scaffold poles is first driven into the ground at the point which is to form the centre of the hut and around these a pad of concrete 9 in. thick and 3 ft. in diameter is poured, as shown in Fig. 14. This is followed by the erection of the main concrete posts and lintels for the wall of the hut. These are indicated at *a* and *b* in Fig. 15. A photograph of the exterior of a completed hut is reproduced in Fig. 20 on page 502. A dwarf concrete wall, or footing, following the circle of the hut, is then formed between adjacent posts. The earth within this enclosure is then removed and a layer of sand screeded off to the top of the dwarf wall; a sheet of jute fabric is then placed over the sand, and is flushed with a 3 to 1 sand-cement grout. Pains are taken to ensure that this grout flows through the jute and reaches the sand below, the fabric being lifted occasionally for this purpose.

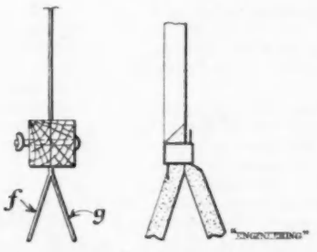












A detail illustrating the arrangement is given in Fig. 17, *a* being the dwarf wall, *b* loose earth, *c* the layer of sand, *d* the jute fabric and *e* the sand-cement layer. The next process consists in driving a crowbar to stiff resistance through the floor and underlying soil, filling the resultant holes with grout and thus forming a series of cast-in-place piles; the concrete floor is then finished off to a thickness of 1 in. The concrete piles are indicated at *p* in Figs. 15 and 16.

A notable feature of this floor construction lies in the fact that the soft earth eventually shrinks from beneath the floor, thus forming an air space. The whole floor structure is therefore a piled foundation in miniature, with an air space providing for warm dry conditions, which is a matter of vital importance where the welfare and health of troops is concerned.

In the next stage, the walls are built; this may be done simultaneously with the roof, or when the latter has been completed. The walls are also formed of jute fabric, inner and outer layers being used, leaving a cavity between. The external fabric requires no fixing, since it contracts substantially when grout is applied, but the internal skin is held in position by nails. Dummy window frames are then erected and drawn together by thumb screws, in the manner indicated in Fig. 18, in which the outer and inner jute fabrics are indicated at *f* and *g*. The two fabric layers are then sewn together round the window openings, the dummy frames removed and the permanent steel frames inserted, as shown in Fig. 19. This latter figure shows the jute fabric after the application of the rendering. Fig. 20, already referred to, shows a completed hut with the wall constructed in this way.

The roof erection is very simple, and may be carried out before or after the completion of the walls. The erection framework for the roof is shown in Fig. 14, which illustrates the manner in which the roof is first put in hand. A ring, made from tube, is erected on tubular scaffold poles at the base of the roof, and a similar small-diameter ring at the apex. This latter is carried by the scaffold poles which were erected in the concrete block at the centre of the hut. The two rings are then connected by radial supports secured by clips. Jute fabric is then placed over this framework, like an umbrella covering, and is flushed with grout in the same manner as the walls and floor. When the grout has set, reinforcement, consisting of No. 12 S.W.G., wire is placed in position. This may take the form either of a spiral or a series of separate rings. The roof is then finished to a thickness of 1½ in. or 2 in. The central holes are then closed by a ventilating flue, small conical roof, or in any other appropriate manner. In the completed hut, a central plate pierced by lights and with ventilating louvres round its edge is used. In the completed roof the stresses are shared by the steel and concrete; the jute fabric acts as shuttering during the placing of the concrete layer. The walls of huts of this type may be constructed in brickwork instead of jute fabric. A recently-erected roof of this type, of 53-ft. span, contains only 7 cwt. of steel and 7½ tons of cement.

Major Waller is also responsible for the Patrick reinforced-concrete hut, and Flexiform roofing. Views of a Patrick hut during erection and after completion are given in Figs. 21 and 22, on page 502. The hut is built up of units consisting of a wall and half-roof section in one piece. Each unit spans a 2-ft. length of the building. The gable-end units, which are designed to connect to the end partitions, are in the form of ribbed buckled plates. Jute fabric treated with cement is used also in the construction of these huts. As will be seen from Figs. 21 and 22, continuous lengths are used to form roof and wall. The fabric is stretched between frames in such a way that the greatest possible strength is developed at the haunch. The fabric, after erection, is treated with cement rendering about 1 in. in thickness. This is merely smeared on and does not require any special skill in its application.

In designing Flexiform roofing the inventor claims to have succeeded in introducing a fireproof construction applicable to all roofs made with rafters. It comprises an under layer of bitumenised material, over which is placed a layer of fibre-toughened fine concrete. When forming the roof, it is laid with a slight dip between each rafter, the purpose of which is to allow for expansion and contraction. Any desired thickness of concrete can be laid on the roof, but for light temporary work Flexiform 1 is generally used; this is supplied in rolls ready for fixing, one layer of fibre and concrete, giving a total thickness of about ⅜ in., being recommended. Where longer life is required, Flexiform 2 is available; this has two layers of fibre with a total thickness of from ⅜ in. to ⅝ in. When fixing this roofing, the material is tacked to the rafters in strips running in one piece from ridge to eaves. A rendering coat of sand and cement is then brushed on the Flexiform surface; any desired number of coats may be applied, with ¼ in. of concrete between each layer of fabric. The cement gun can be used with advantage. An interesting feature is the waved form of this roof. The inventor has found, from experience, that this form of fibre-toughened concrete cracks irregularly when laid with a plain surface. Even in the waved form cracks may appear, but these are usually found at the crest of the wave; such rain as may penetrate the concrete covering must also pass through the flexible waterproof layer before entering the building. Sisalkraft has also been successfully used as a base; this has the advantage that it leaves a clean smooth soffit which may be treated in any desired decorative scheme. This material is also a deterrent to condensation and prevents drips of cement from coming through into the building, and thus making it unusable during construction of the roof. This form of roof covering is claimed to be remarkably resistant to shock, and can be used for the sealing and fireproofing of attics; here it is laid over ceiling joists and built up to the desired thickness. Under present conditions it is recommended that it should be laid with considerable dip between the rafters, so that the incendiary bomb or other missile may come to rest midway between the joists, where it is least likely to cause harm. Flexiform can be supplied to span any rafter spacing up to 5-ft. centres.

The housing of war workers has become an important part of the war effort, which adds interest to the City of Coventry housing scheme; this comprises some 2,000 houses in various parts of the city. It is being carried out under the direction of Mr. D. E. E. Gibson, A.R.I.B.A. One interesting feature of this work is the Myko floor, which has been specially developed for domestic construction by Dr. K. Hajnal-Konyi, M.Inst.Struct.E., in collaboration with Mr. Sidney M. Myers, B.Sc. It is also being employed for housing schemes at Wellington, Salop, and Pennilee, Glasgow, and in the County of Lanarkshire. The Myko floor is adaptable to mass-production methods, an essential condition on housing work of any considerable size. The designers, working in conjunction with the flooring sub-contractors, have succeeded in producing units sufficient to cover from 650 sq. yds. to 700 sq. yds. of floor or roof in one working day. The details of construction are illustrated in Fig. 23, the arrangement consisting of a combination of pre-cast and

DEVELOPMENTS IN CONCRETE-CONSTRUCTION METHODS.

Fig. 20. Exterior of Completed Hut; Waller System.

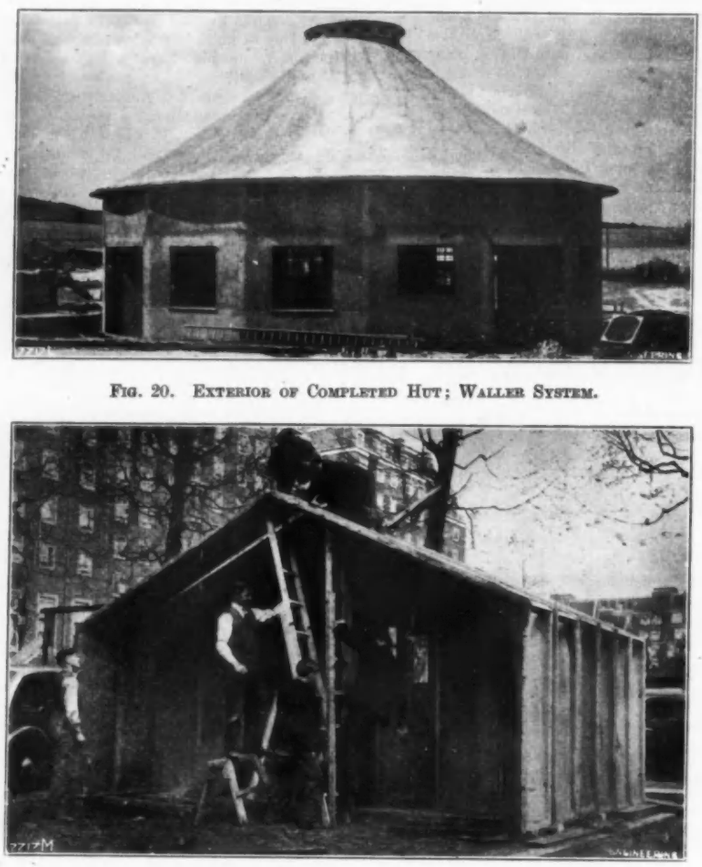
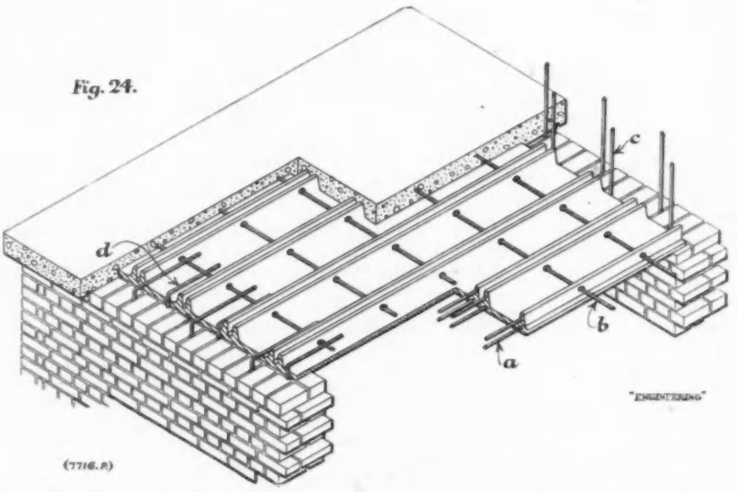


Fig. 21. Erecting Patrick Hut.

Fig. 22. Gable End of Patrick Hut.

cast-in-place concrete. The main beams *a* are of high-grade concrete encased in a skin of foamed-slag concrete. The two types of material are indicated in the figure, the outer layer of foamed-slag concrete being 1 in. thick. Reinforcing stirrups *d* are inserted in the centre of the beams during manufacture and are left projecting for later connection to the reinforcement of the floor. The beams so formed are erected in position on the top of the walls and pre-cast foamed-concrete slabs *b* are laid, side by side, between the beams. These slabs are 18 in. by 9 in. by 2 in. thick. The reinforcing steel *c* of the floor is then laid in position, being interlaced with the projecting reinforcement *d* of the beams *a*. The floor is then finished with a 1½-in. layer of concrete *e*. This fills the spaces between the ends of the slabs so that a T-beam type of floor is produced. For intermediate floors the concrete topping is laid level; for roofs it is laid with a slope to the falls. Ceilings below the floors are formed of plaster boards nailed to the foamed-concrete beams, as shown at *f*.

Pre-cast concrete flooring is now being extensively employed in the construction of surface air-raid shelters. An excellent example of this type of application is furnished by the Bison floor, which is handled by Messrs. Concrete, Limited, of Hounslow, Middlesex. It is illustrated in Fig. 24, on this page. The floor consists of a series of pre-cast troughs. The flanges of the troughs are reinforced by through bars, as shown at *a*, and, in addition, they are formed with holes through which lateral reinforcement *b* is threaded after the slabs have been laid in position for the construction of the shelter roof. These holes are at 18-in. centres, the slabs being 14 in. wide. The reinforcement of the walls, left projecting when they are built, as shown at *c*, is bent over and lies in the troughs, as at *d*,



when the slabs are in position. This forms a good tie at the haunching. The floor or roof is completed by the laying of the *in-situ* concrete surface layer. Another interesting idea is the Bison *in-situ* hollow floor, which is formed by means of a canvas covered rubber air bag; this is withdrawn when the concrete has set. It acts as a pneumatic core. These air bags are used over and over again. The floor, when completed, is very similar to one of conventional hollow tile construction. After the soffit concrete has been laid and levelled, the inflated cores are placed in position, one end of each core being turned up to enable the solid ends to be formed, a holding-down bar being secured in this position. Reinforcement is then arranged between the cores, after which the concrete floor proper is poured and screeded. The cores are then deflated and withdrawn. The obvious saving in time and material hardly needs to be stressed.

In these days it would be valuable for any engineer charged with the design or construction of buildings, to study the recent *Report on Buildings Damaged by Air Raids, and Notes Relative to Reconstruction*, prepared by a Committee of the Insti-

tution of Structural Engineers. Three paragraphs of this report are particularly noteworthy and justify quotation in full:—"The behaviour of framed buildings, both steel and concrete, has proved to be very satisfactory and it is the opinion of the Committee that such structures have stood up to attack in the most remarkable manner and have shown great powers of resistance and resilience. They have withstood attacks from bombs of the heaviest calibre where buildings with brick walls and timber floors have collapsed utterly under the action of small bombs. For buildings of the future the Committee feels that framed buildings of steel or of reinforced concrete with reinforced concrete floors deserve to be adopted, even when no advantage in cost is apparent, owing to their resilience and resistance to all kinds of forces for which they were not primarily designed, but to which they may in future become subject. Other things being equal, structures in which all the beams are properly connected to the columns in accordance with good modern practice are to be preferred to structures in which members are free to act as independent units."

The problems of post-war reconstruction are now receiving intensive study, and we must visualise a complete standardisation of building materials when we come to tackle the job. There is no doubt that many war-time building expedients will be adapted to the pressing needs of that difficult period. Rapid construction and rigid economy of materials will be keynotes of design, and the author has no doubt that pre-cast concrete construction will fulfil many of these requirements. Finally, it should not be difficult to convert war-time manufacturing plants of certain types to the large-scale production of building units and materials.

THE INDUSTRIAL HISTORY OF RUSSIA—II.*

By ENGINEER CAPTAIN EDGAR C. SMITH, O.B.E., R.N.

THE measures taken by Peter the Great to develop the resources of his empire, referred to on page 424, *ante*, were not confined to shipbuilding, mining and metal working, but covered also the textile, leather, glass, paper and other industries. Then, too, he inaugurated an era of scientific exploration. Navigators, men of science and others, as time went on, travelled the whole country from the Baltic to the Pacific, and from the Arctic to the Caspian. He also stimulated the progress of education and the multiplication of books, and prepared the way for the application of science to national needs. In all these things he was essentially the pioneer, and Russia has had no other ruler of the same calibre, except the famous Catherine the Great, who reigned from 1762 to 1796. It was during her reign that the steam engine, and mechanical engineering generally, found their way into Russia.

Of the textile industries of Russia, those of flax and hemp manufacture are among the oldest and most important. To further their development, Peter granted special privileges to linen manufacturers, and inasmuch as sail cloth and rope were absolute necessities for his fleets, he placed their manufacture under the control of the Admiralty. To encourage the wool industry, he secured the services of foreign sheep farmers, and ordered that the army was to be supplied only with Russian cloth. From abroad, too, he engaged curriers for the leather industry. His reign saw the erection of the first silk mill, the first Government paper factory, and an Imperial Glass Works. A domestic cotton industry, using foreign yarn, was then springing up in the government of Vladimir, and here, about 1745-50, the first dyeing and calico-printing works was established. Of special importance in the history of the Russian textile industry was the founding, at the end of the Eighteenth Century, of the Alexandrovsk State Manufactory, famous for its canvas, where the first power loom in Russia was set up in 1808. Flax-spinning machinery of British make was sent to Russia in 1820, the Girard machine was introduced in 1827-30, and the Jacquard loom was used in silk factories at about the same time. When James Nasmyth visited St. Petersburg in 1843, he found his countryman, General Alexander Wilson, in charge to the two State establishments at Alexandrovsk and Colpenha, with some 3,000 employees. At Colpenha there was a foundry, a machine shop and a mint, the last having been supplied to the Government from Soho, under an Act of Parliament of 1799, passed "to enable Matthew Boulton engineer to export the Machinery necessary for erecting a Mint in the Dominions of His Imperial Majesty the Emperor of all the Russias."

That a knowledge of experimental science was slowly spreading throughout Russia in the Eighteenth Century is evident from the fact that Polzunow, away in the depths of Siberia, was able to construct a Newcomen engine.

Mining engineers, prisoners of war, and educated exiles did much to carry learning eastward, but the principal scientific body was the Imperial Academy of Sciences of St. Petersburg; planned by Peter, but inaugurated in 1725, just after his death, by his widow Catherine I. Its earliest members included German naturalists, a French astronomer, and the two Swiss mathematicians, Daniel Bernoulli and Leonard Euler, whose reputations became world-wide. Bernoulli only stayed in Russia for a few years, but St. Petersburg was Euler's home from 1727 to 1741 and again from 1766 until his death in 1783. His services to his adopted country were outstanding. It was in St. Petersburg, in 1753, that Professor Richmann fell a victim to lightning while repeating Franklin's experiments, and there, in 1759, Professor Braun first artificially congealed mercury. The University of St. Petersburg was founded in 1747, and that of Moscow in 1753. In 1760, Euler's pupil Rumoffski published his *Course of Mathematics*, said to be the first printed in the Russian language. The Academy of Sciences was largely responsible for the arrangement of the scientific expeditions referred to. One of these lasted for ten years, and another for about six years. They brought back a wealth of information about the great land of Siberia, which is of so much importance to Russia to-day. The geological information gained, it is true, was not so valuable as that relating to climate, flora, fauna, soils, races and so forth, for geology as a science was practically unknown; the very term "geology" had not been invented. Geological exploration had to wait for the Nineteenth Century.

The introduction of mechanical engineering into Russia took place in the latter part of the reign of Catherine the Great. It was then that British engineers carried to Russia the practices of the Carron Iron Works and of Boulton and Watt, and Russian mechanics were sent to Britain to learn what they could about steam engines. A part of the story was told in a paper by Professor P. P. Zabarinskij, entitled "The Earliest News of Watt's Steam Engine to reach Russia," read to the Newcomen Society in January, 1936, and published in vol. XVI of the Society's *Transactions*. In that paper, reference is made to the Newcomen engine designed by Smeaton, made by the Carron Company, and erected at Cronstadt in 1774. Prominent figures in Russian naval circles about this time were Admiral Sir Samuel Greig (1735-88), Admiral Sir Charles Knowles (*d.* 1777) and his secretary, John Robison (1729-1805), the friend of James Watt. Greig was responsible for fortifying Cronstadt, Knowles was at the Admiralty, and Robison was in charge of naval education. Both Greig and Robison knew of the Carron Iron Works and it is not surprising, therefore, that the contract for the Cronstadt engine went to Falkirk. Soon after his arrival in Russia, Robison wrote to Watt, asking him if he would like to go to Russia as "Master Founder of Iron Ordnance to Her Imperial Majesty." A little later he wrote again, this time asking Watt to undertake to erect a pumping engine for the Cronstadt dry dock, to replace the wind mills. Watt declined both invitations and practically told Robison he was quite capable of erecting an engine himself. Watt at this time was largely concerned with civil engineering and had not become connected in business with Boulton. Already, Boulton's fame had reached Russia, not as an engine builder, but as a maker of metal trinkets and ornaments. In 1770, he had sent Catherine two clocks; he had entertained Russian notabilities at Soho, and was well-known to the Russian ambassador. One day in 1776, he wrote to Watt that "the Empress of Russia is now at my house, and a charming woman she is"; but he was apparently referring to a portrait of the Empress, for there is no evidence that Catherine ever visited England, much less Birmingham.

The connection of the Carron Company with Russia was strengthened later when, in 1786, the principal director visited St. Petersburg. Through Greig, it was arranged that the company should erect a gun factory. With the director went young Charles Baird (1766-1843), an ex-apprentice of the firm who, during the next three years, was responsible for the erection of Alexandrovsk gun works and the Kouchesevsky blast furnaces, and who then made Russia his home. Allying himself in business with a Mr. Morgan, whose daughter he married, Baird was enabled to open a foundry, machine shop and shipyard on an island in St. Petersburg. In 1810 he was joined by his nephew, William Handyside (1793-1850), and in 1819 by his son, Francis Baird (1802-64), who, after his father's death became the sole proprietor of the works. The concern flourished apace. Contracts were carried out for the Arsenal and the Imperial Glass Works, suspension bridges were built, steam engines constructed, and a monopoly in steamboat building was secured. Among the most notable work done was the casting of the great bas-reliefs on the pedestal of the Alexander Column. In T. Tower's Memoir of the Bairds, it is stated that, in 1852, Francis Baird "emancipated all the numerous serfs on his estate, amounting to 446 souls, in advance of the general emancipation which sheds such immortal honour as the present Emperor" (Alexander II).

The Leeds firm of Fenton, Murray and Wood also did business with Russia, possibly first through the supply of flax machinery. The second Matthew Murray (1793-1835), only son of Matthew Murray (1765-1826), went to Russia about 1821, taking with him a model locomotive, and set up in business in Moscow. Not much is known of his activities, but in a letter dated January 21, 1827, he said: "I have made the Drawings and Estimates for Government, for supplying the town of Mosco with Water, and xpect the Order very soon, there will be two 24H Engines in one House, pumping thro' Iron Pipes into an elevated Iron Cistern, at a distance of 3 Miles from the Engines, from which Cistern it is conducted by Iron pipes thro' the different streets of Mosco, this is an immense Job, and will take me about 3 Years. I have had some Opposition from Baird, but I hear he has dropt it, meeting no Encouragement." Both this Matthew Murray, and his nephew, Matthew Murray III, (1816-82) died in Russia. Another Englishman to whom Russia owed something a hundred and fifty years ago was Sir Samuel Bentham (1757-1831), who knew as much as any man of his time about dockyards and their organisation.

As might be expected in a country with but few engineering shops, and where illiteracy and serfdom still held sway, the progress of steam navigation was very slow. Thousands of craft on the inland waterways of Russia continued to be moved by oars, sails or horse-worked capstans long after steam had become the main motive power on the great rivers of America. The first steamboat built in Russia was the Elizabeth, constructed and engined by Baird in 1815. Next came the Skory (Swift), built for the naval department at the Iron Works at Izhora, near St. Petersburg, in 1817. In that year, Baird was granted a monopoly in steam navigation in Russia, lasting until 1843. The privilege, however, could have benefited little either the firm or the country. Nine years after the monopoly lapsed, there were only 148 steamboats afloat. By 1869, however, the number had increased to 623. Up to 1840, the Navy had secured about a score of small steam vessels, and, between 1840 and 1850, eleven steam frigates with engines of from 200 horse-power to 500 horse-power were added to the fleet. As in this country, the Crimean war led to the con-

* The previous article appeared in ENGINEERING of November 28, 1941, page 424.

struction of a considerable number of gunboats, with high-pressure engines. When the war was over, not only the supply of ships and engines, but everything connected with the naval service underwent reorganisation. Russia's first ironclad was the Prevenets (the Firstborn), built in 1863 on the Thames. Ten years later, at Cronstadt, the Russians were building the Peter the Great, of 9,510 tons, carrying four 12-in. guns and considered at that time to be the match of any ship afloat.

The earliest railway in Russia was that from St. Petersburg to Pavlovsk, 17 miles in length, known as the Czarskoselo Railway. It was planned by the Czech engineer, Franz Anton von Gerstner (1793-1840), and was opened on April 17, 1838. The next line was that from St. Petersburg to Moscow, the engineer of which was Major Whistler, father of the famous American artist, James Whistler. It was in the hope of obtaining orders for locomotives for this line that Nasmyth visited Russia, but, like other locomotive builders, he found that the Emperor Nicholas was anxious for the rolling stock to be constructed in Russia. To achieve this, in 1844, the Alexandrovsk Crown Iron Casting and Mechanical Works was turned over to the American Company which, during the course of twenty-four years, built 200 locomotives, 253 passenger carriages, and 2,700 freight wagons. Later, locomotive construction was carried on at the Nevsk works in St. Petersburg, the Kolomensk and Briansk works in central Russia, and at the Votkinsk works in the Urals. A general review of the Russian railways was given in *The Engineer* of February 4, 1938, by Mr. F. R. Wilson.

The initial steps in the mechanical engineering industry, it will be seen, led to no immediate large-scale developments. The growth of both railway transport and steam navigation was slow, wood remained the principal fuel for domestic and industrial purposes, and the supply of cast iron and manufactured iron was only sufficient for local needs. After the middle of the Nineteenth Century, however, there was increased activity in many directions. This activity was stimulated firstly by the national emergency caused by the war of 1854-56; secondly, by the emancipation, in 1861, of some 47,000,000 serfs, and thirdly, by the extension of the railways, the length of which increased from about 1,000 miles in 1860 to some 15,000 miles in 1880. Disregarding the coal and iron industry of Poland, which has never properly formed one of the Russias, the most notable development in the coal and iron industries took place in the Donetz basin, where, for the first time, Russian iron ore was smelted on a large scale by the use of coal. During his geological expeditions of 1841-5, Murchison spent a month exploring the region of the Donetz river and in the fine geological map given with his monumental work *The Geology of Russia in Europe and the Ural Mountains*, the sites of the coal mines then in existence are all shown. They are all practically in the area bounded by the bend of the river and the coast of the Sea of Azof from Rostov to Mariupol. Some of the mines supplied coal to large foundries at Lugan, built in 1797, and Murchison stated that the first shafts were sunk by a Scottish miner, Gascoigne, and some of his countrymen. There were no British residents there in 1842, but British mining terms were still in use. It was at the Lugan iron works that repeated, but unsuccessful, attempts were made to make pig iron from local ores and coal. This problem was finally solved by the Welsh ironmaster, John Hughes, who had held a position with the Millwall Iron and Shipbuilding Works on the Thames. In 1869, Hughes was granted a concession for the erection of blast furnaces and a rolling mill in South Russia. Accordingly, the New Russia Company was formed, and Hughes and his sons started to build works on the banks of the River Kalmius, which enters the Sea of Azof not far from Taganrog. The first blast furnace was blown-in in April, 1871, and the second in 1876. By 1885, according to an article in *The Mechanical World* of August 6, 1885, there were three blast furnaces, producing 900 tons to 1,000 tons a week, and, with the use of the Siemens-Martin process, about 700 tons of steel rails were being made weekly. Some 3,000 men were employed at the works, which had caused the building of a town of 8,000 inhabitants, called Hughesoffka.

Such, briefly, are some of the main events connected with the industrial history of Russia. Those who may desire to learn more of the state of the manufactures and trade of the country half a century ago will find ample material in the five volumes on *The Industries of Russia*, published by the Russian Government in connection with the exhibits shown at the World's Columbian Exposition at Chicago in 1893.

LITERATURE.

Road Accidents in War Time. By DR. H. M. VERNON. Cambridge: W. Haffer and Sons, Limited. [Price 3s. 6d. net.]

So much has been written on the subject of "the toll of the road" that any further study of the causes and possible prevention of accidents might appear, at first sight, to be redundant; or, at least, in the middle of a war, somewhat ill-timed, since the conditions now obtaining cannot present a very accurate picture of those that will certainly develop after the war. For a short time after the cessation of hostilities, there is not likely to be any greatly increased congestion of traffic; but when petrol becomes more freely available, and the automobile industry begins to implement its promises of more and cheaper cars than ever before, there is danger that the accident rate may show a sharp upward trend, and that another spate of hasty legislation may burst upon the community, without a sufficiently calm and judicial consideration of the problem in all its many aspects. Dr. Vernon's study is a gratifyingly sober attempt to examine these aspects so far as can be done on the basis of recent statistics. For all practical purposes, it begins with the figures for 1928, when 6,138 persons were killed and 164,838 were injured; and the survey is continued down to the twelve months ended in August, 1941, when the number killed rose to the record total of 10,073, in spite of a 20-m.p.h. speed limit during black-out hours and a greatly reduced volume of private traffic. A curious feature of the returns for the latter period is that, while the black-out accidents were less numerous than in the preceding twelve months, the daylight accidents, in the six months from September, 1940, to February, 1941, were 53 per cent. in excess of those for the corresponding months of 1939-40.

Dr. Vernon probes the subject deeply, and, so far as the presentation of the relevant statistics and the quotation of the comments and findings of others are concerned, he does so with commendable fairness. Occasionally, however, he lapses into statements of the *post hoc, ergo propter hoc* order. For example, in discussing the effect of banning the use of motor horns, he says that "in Finland, where they are forbidden except in open country, accidents have been reduced to about a half by reason of the regulation, and the ban in Rome has resulted in a large reduction in the number of accidents." Is it certain that there were no other influences at work? He is not alone in making such statements, for he quotes Lord Alness's Committee as having cited evidence, in support of their recommendation that trolley 'buses should be substituted for tramways, that "on one road this change resulted in a reduction of accidents by 33 per cent." In none of these cases should we regard the conclusion as fully proven without much more detailed knowledge of all the circumstances.

Chapter IX of the book is entitled "General Conclusions," but, in fact, it is mainly a summary of the evidence adduced in the previous chapters. The author has no single panacea to offer; though this is rather a recommendation of his work than otherwise, for it is clear that there are many contributory causes of the high accident rate. Undoubtedly, there are (as he quotes from *The Times*) "two modes of outlook on road safety problems, the 'motoring outlook' and the 'pedestrian outlook.' The former detests regulation and pins its faith on education and safety campaigns, while the latter advocates regulation." We would suggest, however, that the motorist detests regulation mainly because it has been so often applied unfairly; and that the pedestrian demands it because, from time immemorial, he has enjoyed the prior right to the road and is unwilling either to relinquish it or to submit to regulation himself. Education of the public, and especially of children, ought to have produced better effects than it appears to have done so far; but if and when it is extended to include, in every secondary school, lessons in driving and the elementary mechanics of the motor-car, there should be a marked improvement. These are but a few of the reflections stimulated by a perusal of this carefully compiled book. It is likely to have many different effects on the minds of different readers, but it cannot fail to impress on all the seriousness and complexity of the problem of road casualties, and the need that it should be re-examined with the greatest care before any more repressive or savagely punitive legislation is drafted.

Materials and Structures. By D. A. R. CLARK, M.Sc.Tech., A.M.I.Mech.E. London and Glasgow: Blackie and Son, Limited. [Price 25s. net.]

To carry a student from the elementary stages of the extensive subjects of materials and structures to the standard of the London University degree examination and those of the major engineering institutions is a considerable undertaking, but Mr. Clark appears to accomplish it successfully in this concise, yet comprehensive text-book. He achieves this end by a notably compact style of expression, supplemented by many attractively simple diagrams, and the generous employment of examples and test questions drawn from the examinations for which the book is a preparation. At the same time, he does not merely paraphrase the many texts that have appeared before, but develops his arguments logically, and interposes frequent comments that give an added interest to the familiar basic principles and conceptions, and also indicates that his own reading has covered a wider range than mere routine prescribes. Every text-book of this kind refers to "the modulus of elasticity, or Young's modulus," for example; but Mr. Clark comments, in passing, that "both names frequently occur. (Young himself spoke of the 'modulus of elasticity')." A small matter, perhaps; but little touches like this are undoubtedly stimulating to the imagination and the memory of the student, and make a difference in the readability of a book that is often out of all proportion to their intrinsic importance.

The sixteen chapters cover not only the usual studies of beams and bending, torsional and compound stresses, columns, and framed structures; but, in connection with the production of metals and the testing of materials, cover a wide range of associated subjects. Cement, concrete, timber and plastics are not overlooked, although naturally they cannot be treated exhaustively in the limited space available. There is a separate chapter on influence lines, and attention is also given to the elements of the design of suspension bridges and of masonry structures. The book concludes with a short bibliography of up-to-date references, mainly to papers read before various institutions; and there is an adequate index. A feature that is somewhat unusual in text-books originating in this country is the adoption of a new series of illustration numbers for each chapter. Possibly it has advantages, but many readers would probably prefer the illustrations to be numbered consecutively through the book.

ROYAL METEOROLOGICAL SOCIETY.—The Council of the Royal Meteorological Society has awarded the Symons Gold Medal for 1942 to the late Dr. J. S. Owens, an obituary notice of whom appeared on page 475, *ante*.

JUBILEE OF THE INSTITUTION OF MINING AND METALLURGY.—The first meeting for the purpose of forming the Institution of Mining and Metallurgy was held in the City of London on January 13, 1892. To mark the fiftieth anniversary of that meeting the Council has decided to hold a luncheon, which is to take place at the Savoy Hotel, London, W.C.2, on Tuesday, January 13, 1942, at 12.45 p.m. for 1 p.m. Tickets may be obtained on application to the Secretary of the Institution, The Royal School of Mines, London, S.W.7.

THE ORIGIN AND MANUFACTURE OF WOOD SCREWS.*

By DR H. W. DICKINSON.

(*Concluded from page* 496.)

MR. ANGELL, of the Eagle Screw Company, was quick to realise that the blunt screw, for which alone his machinery was adapted, would soon be supplanted by the pointed screw; and at this juncture got into touch with Thomas J. Sloan, of New York, who, in 1846, had patented (August 20, No. 4704) and (November 24, No. 4864) a machine to make pointed screws. In the specification of the first patent, Sloan says: "Screws have heretofore been formed gradually tapering at the core from where the thread starts to the end by dressing the thread at each turn, and tapering screws have also been formed; but they have been found not to hold as well as those of common construction by reason of the taper of the main part of the core." His patents had been offered to the New England Company, but were declined. Evidently, Angell was satisfied that there was sufficient novelty in Sloan's machine to obviate the possibility of an action for infringement by Whipple and the Eagle Company. He took up the patent, his machines were altered, and soon his company was able to share in the prosperity. In 1856, a sales agreement and fixed prices among the principal competitors were arranged.

In 1860, the Eagle and the New England Companies amalgamated under the name of the American Screw Company, with a capital of 1,000,000 dols. Later in the same year, the new company bought out the Utica Screw Company, of Utica, N.Y. In 1861, the American Company purchased the Bay State Screw Company, of Taunton, Massachusetts, chartered in 1852. In 1873, the business and the machinery of the latter were transferred to Providence and a new mill, to which, in consequence, the name Bay State Mill was given, was erected. The progress of the new company during the remaining ten years of Angell's life was continuous and rapid, and this was the more noteworthy because more than 70 companies that had engaged in this line of business had been unsuccessful. He was the guiding spirit, combining a grasp of the mechanical, the commercial and the legal sides of the business. Thus, the State of Rhode Island may justly claim the distinction of being not only the cradle, but the nursery and home, of the wood-screw industry in the United States.

We must now hark back to England, where the superior American-made screws were gaining a foothold. Nettlefold entered into negotiations with Thomas J. Sloan, to acquire his English patents, which had been taken out in the name of his patent agent, Newton. The price asked was so high that, although Nettlefold was determined to secure them, he was unable to do so as he did not possess the necessary capital. He had married Martha Chamberlain, and her brother, Joseph, a London merchant, advanced the necessary sum of 30,000*l.*; the firm became Nettlefold and Chamberlain. After negotiations extending over two years, the Birmingham works were equipped, in 1854, with the new machinery imported from the United States. John Henry Nettlefold, son of the founder, became the works manager, and his cousin Joseph, son of the above Joseph, then only 18 years of age, was given the commercial management. The increased field of usefulness of the screw, and the lowering of price, reacted on the sales to an unforeseen extent and the increased output further reduced costs. New premises were established in Heath-street, Smethwick, which remains the firm's largest factory for screws. Competitors were bought out, and in this way James and Amery, in 1866, and the Birmingham Screw Company, in 1880, were acquired; the Imperial Mills site for cognate products was acquired in 1869. In 1874, Joseph Chamberlain retired to devote his time to municipal and political activities, and the firm became Nettlefolds, Limited. In 1886, the supply of wire of the necessary machining quality and diameter was ensured by the establishment of the Castle Works, Rogerstone, South Wales; and, in 1902, a further step in vertical integration was taken by combining with Guest, Keen and Company, steel manufacturers, under the new name of Guest, Keen and Nettlefolds, Limited.

We now return to the United States, where further progress has to be recorded. Experience shows that the weak point in a wood screw is where the change of section at the start of the thread takes place. To avoid this had long been the aim of manufacturers, but success was not attained till Charles D. Rogers (1827-1903) patented in 1876 and brought out a screw in which the core of the screw part tapers into the shank and the thread consequently runs out to nothing. Another of Rogers's inventions is the "drive screw," which is a true screw nail; it has a quadruple-fluted thread and a spear point. It will turn like the screw when driven by a hammer, but, alternatively, can be driven by a screw-driver; it is cheaper than the ordinary screw. In 1887-92, Rogers brought out the "cold forged screw." The wire is upset in four stages to form the head and tapered shank, the slit is forged, and the point formed. The thread is then swaged up in five more cold stages; the screw thus has a tapered shank, a parallel core and a spear point. As in the preceding case, the surface skin is unbroken.

In 1891, the American Screw Company started a subsidiary company in this country with the title of the British Screw Company, under the management of Mr. C. L. Rogers (son of C. D. Rogers) and of Mr. F. G. Langee. Leeds was chosen as the headquarters, a factory was built there, and a number of workpeople were sent over from the United States to train local factory workers. Some of the second generation of these are still in the employ of the firm. In 1899, the American firm sold the business to English capitalists. Besides ordinary screws, the Rogers rolled-thread screws were made in Leeds, but they did not prove popular in this country and the manufacture was discontinued. Objection was raised to the shank being less in diameter than the threaded portion, a condition inseparable from the process, unless the thread is carried up to the head. Recently, screws of the last-named kind have been made by the Parker-Kalon Corporation, of New York, for jointing sheet metal, and for that purpose are hardened so that they form their own thread in the soft sheet metal. These are made in this country by Nettlefolds. The Rogers drive screw was made at Leeds until quite recently, but now the "B.S." drive screw is being made instead, the reasons being mainly one of economy; for, whereas the former needed two or even three blows on the wire to form the head, only one blow is needed and blanks can be forged cold at the rate of 160 per minute to 260 per minute, according to size.

Wood screws must have been made by hand in France in the Eighteenth Century. The first patent recorded after the establishment of the French patent system was that granted to Japy Frères, clock and watch makers, of Beaucourt, near Belfort, département du Haut-Rhin, in 1806. Frederic Japy had established himself there in 1780 and, about 1805, handed on the business to his five sons. When they began making wood screws is not stated, but it was probably in the latter year. The first start in factory production in France must be credited to them. In 1809, they submitted to the Société d'Encouragement "a card of specimen wood screws of which the head was struck in a flypress. It is to the credit of these distinguished artists that they have given the finishing touches all at once to so important a manufacture . . . Already they employ in this manufacture about 250 workpeople, for the most part women and children. They make large supplies for naval construction at the port of Antwerp and for footwear of the troops; the small screws with which the soles of the shoes of the soldiers are furnished only cost a sou per dozen." It is doubtless this firm that Bodmer alludes to, *ante*, under the name of "Chappis of Beaucourt."

Several patents were granted subsequently: for example, that of F. Phillix, of Marseilles (1812) for "*Machine propre à fabriquer les clous à vis pour le bois*"; the enrolled drawing is not wholly intelligible, but shows no advance on the existing practice in England. It proves that screws were being made at quite the other extremity of the country. An important patent was that of Japy Frères (1845), "*Système de fabrication de la vis à bois.*" Apparently this firm took up Sloan's French patents about the same time as Nettlefold did his British patents. So far as we can learn, progress since then has been *pari passu* with that in Britain and America.

The wood-screw manufacture was introduced into Germany in Westphalia in 1861 by Timke and Hueck, of Hagen, with the help of English workmen. In the '80s the rolling of wood screws under the patent of the Harvey Screw Company, of Jersey City was taken up; such screws did not, however, enter into competition with the ordinary ones. In 1891, Henry E. Coy, of Toledo (United States Pat. No. 448,638), used a milling cutter for threading, and this has received much application in Germany. Allenloh, Brinck and Company, of Milspe, in Westphalia, built a large factory and have made a big proportion of their output in this way. The industry continues to be carried on largely in the Rhineland. Small sizes up to 10 mm. long and 2 mm. in diameter have been made from the solid rod; above that size, the metal to be removed is so great as to render the method uneconomical. Screw making has been established in Sweden and in Switzerland, but the date and details are unknown to the writer.

There have been a number of attempts to produce large wood screws by casting in metal. The earliest we have come across is that of Richard Maullin, of Coseley, Staffordshire, who patented (1800, No. 2379) a "machine to mould patterns for casting wood, bed and other screws of cast iron, brass or other metall composition." The interest of this process is that a number of identical patterns were to be attached to one plate and mechanism provided to screw them into the sand to make their own moulds, perhaps the earliest instance of plate moulding. It was before the days of malleable iron, however, and the product must have been brittle and unreliable, so that it is not surprising that nothing further is heard of them.* The method, or something very like it, was patented by James Warren in 1841-46 (Nos. 9042 and 11363). As his product was malleabilised, it might have been thought that, for large screws, such as coach screws, it would have found a market. It has been suggested that it was these screws that were shown by the Patent Pointed Screw Company in the Great Exhibition of 1851, but the writer has been unable to find whether this was the case, or what happened to the process.

The diameters of wood screws were standardised in this country to the writer's knowledge, in 1883, and probably it was done as early as 1852. These sizes run the reverse way to that of the Imperial Standard Wire Gauge, *i.e.*, the low numbers are the small sizes. Diameters of American, French, German and Swedish wood screws are likewise standardised; while they differ from each other, yet there is some consonance among them, particularly between the English and the American, pointing to a common origin, but the writer has been unable to establish this. The German sizes approach the British fairly closely, as might be expected. The English screw gauge runs from 00 = 0·038 in. in diameter to 40 = 0·602 in.; it will be observed that the intervals between the sizes are less than those between the sizes of the I.W.G. A selection of a few sizes of different gauges and countries expressed in decimals of an inch is given in Table I, below. Germany, in company with Sweden and Switzerland, has gone farther and has standardised the angle of thread at 60 deg.

TABLE I.—*Sizes of Wood Screws.*

Size.	British.	American.	French.	German.
0	0·052	0·0578	—	0·0649
10	0·192	0·1894	0·0570	0·1811
20	0·332	0·3210	0·1574	0·3385
30	0·472	0·4520	0·4133	—
40	0·602	0·5842	0·7677	—

The progress of the wood-screw trade must strike an observer as phenomenal. Chamberlain stated that the production in Great Britain in 1800 was 98,800 gross; this increased by 1849 to 3,640,000 gross, and by 1866, to 6,760,000 gross. The price in 1849 was about one-fifth of what it was at the beginning of the century, while the reduction between 1849 and 1866 was another 50 per cent. In 1935 the production was 24,240,000 gross of wood screws, requiring 10,900 tons of steel and valued at 703,000*l.* The production of coach screws was 103,000 gross, requiring 1,200 tons of steel and valued at 26,000*l.* In addition, an estimated quantity of 3,250,000 gross of "brass" wood screws using 1,500 tons of gunmetal, and of the value of 262,000*l.*, was produced. Of the whole, one-quarter in quantity and one-fifth in value was exported. In Germany, before the Great War, the output was 12 million to 15 million gross. It is assumed that the production in France was much the same as that in Germany. Sweden, also Switzerland, has a considerable output, while that of the United States is of the same order, if not larger than that of this country. Between them, the countries mentioned supply the world's needs. The question arises in the mind, as in the case of pins and buttons: "Where do they all go?"

* Paper read before the Newcomen Society at Birmingham on Wednesday, December 10, 1941. Abridged.

* The process of making cast iron malleable was patented by Samuel Lucas in 1804 (May 30, No. 2767).

THE INSTITUTION OF FIRE ENGINEERS.—The graduateship and associate-membership examinations of the Institution of Fire Engineers will be held in London and at various other centres on Saturday, March 21, 1942. Applications to sit for the examinations must be received by the secretary, 2, Millbank House, Great Peter-street, London, S.W.1, not later than February 15, 1942.

MILITARY PREPARATIONS IN THE UNITED STATES; ERRATUM.—On page 473, *ante*, we gave an account of a joint meeting of the American Society of Civil Engineers and the Chicago Chamber of Commerce, held at Chicago, at which the speaker was Brigadier-General Brehon B. Somervell. Although his name appeared correctly in the page proof, it was omitted, when the page was printed, and only the title of Brigadier-General remained.

ARGENTINE PETROLEUM PRODUCTION.—Statistics issued by the Argentine Government indicate that the output of petroleum during the first seven months of the present year totalled 1,986,520 cub. metres, of which the national oilfields produced 1,262,452 cub. metres. During the corresponding period of 1940 the total output of the country was 1,851,784 cub. metres. The increase of 134,736 cub. metres during 1941 represents a rise of 7·2 per cent.

SMALL-ARMS BARREL-FINISHING MACHINES.

Since the mass-production of small arms originated in the United States, it was to be expected that the manufacture of machine tools for the industry should keep pace with development in small-arms design in that country. An example is afforded by the range of machine tools for drilling, reaming, rifling and chambering the bores of rifles, machine guns and revolvers manufactured by Messrs. The Builders Iron Foundry, Providence, Rhode Island, U.S.A., the sole agents for whom, in Great Britain, are Messrs. Alfred Herbert, Limited, Coventry. A short account of the four machines enumerated above, is given below, though we are able to illustrate only two of them, namely, the reaming machine, Fig. 1, and the rifling machine, Fig. 2, on this page. It may be mentioned that the drilling and chambering machines are also of the horizontal type.

The drilling machine has two spindles, for two barrels, and will drill holes up to 0·875 in. in diameter by either 20 in. or 3 ft. 6 in. long, according to the length of the bed. Each spindle is belt-driven by a separate motor and has a single speed of 1,500 r.p.m. The work is held in a chuck on the spindle nose and is carried at the feed end in a movable bushed support, which also has a bush for guiding the drill. The drills do not rotate and each is held by the shank in a collet mounted on a tailstock, which is traversed, to give the feed, by an independent lead screw and half nut. A range of 12 feed rates is provided by means of pick-off gears, and hand traverse is also available. The drills are supported between the work supports, and the collets by bushed steady rests sliding on the ways of the bed. Drill breakage is guarded against by an adjustable friction clutch in each headstock, which is set to slip under excessive torque, both the spindle rotation and the tailstock feed being then stopped. The clutch may also be controlled by a hand lever or may be arranged for automatic release at any desired point by means of a dog. The cutting lubricant is supplied by two gear pumps driven by the spindle motors. The pumps discharge to the tailstocks, then through holes in the drills to the cutting edges. Strainers are fitted on the suction side of the pumps.

The reaming machine shown in Fig. 1, like the drilling machine, has two spindles, but in it the work is stationary, while the tools rotate. The headstock is seen at the left of the figure, a main shaft within it, belt-driven from a 5-h.p. motor, being geared to the two spindles. Three spindle speeds are provided by using driving pulleys of different diameters. The work is carried on the two long saddles seen at the right, and is supported at one end on a simple rest and held at the other by a swivelling clamp, which permits the necessary amount of "float," but prevents rotation. The reamers have long shanks, which are threaded through the drilled barrels when the saddles are close up to the headstock and are held in the spindle chucks. In this position of the saddles, the cutting edges of the reamers project beyond the work. To perform the reaming operation, the saddles are traversed away from the headstock, this movement drawing the work over the rotating tools. The saddle traverse is by rack and pinion, the pinion motion being derived from feed shafts which are driven from shafts in the headstock, the latter shafts being driven from the spindles. The saddles can be traversed, either singly or together, in either direction, the change-over being obtained by clutch control. Stops are provided to enable the automatic feed of the saddles to be tripped at any point. The saddles can also be given feeding motion by hand. The pedals seen about midway along the bed can be used for stopping either of the spindles through a clutch. The cutting lubricant is supplied in a manner similar to that of the drilling machine. The reaming capacity is 0·875 in. in diameter by 19 in., or 4 ft. 2 in. long, according to the length of the machine bed.

The rifling machine is shown in Fig. 2. It deals with only one barrel at a time and will accurately index and machine from 2 grooves to 8 grooves in bores up to 4 ft. 2 in. in length. The shortest helix that can be cut is one turn in 8 in., and the longest is one turn in 20 in. The tool is stationary in a longitudinal direction, the work being traversed along the bed, and being given a rotating indexing movement; it is held in a chuck on the traversing saddle, and makes a forward and return stroke. The cutter is retracted during the forward stroke, the cut being made on the return stroke, during which it is rotated as necessary for forming the desired helix by mechanism actuated by the sine-bar gear seen at the centre of the machine. At the end of each forward stroke the work is automatically rotated into the position for the next groove, and is thereafter held rigidly by the indexing mechanism during the return stroke. At the end of each complete revolution of the index plate, the cutter is given an outward feed movement preparatory to taking a deeper cut. The machine is belt-driven by a motor mounted on an adjustable base below the bed. There are two belts, open and crossed respectively, for

SMALL-ARMS BARREL-FINISHING MACHINES.

MESSRS. THE BUILDERS IRON FOUNDRY, PROVIDENCE, R.I., U.S.A.

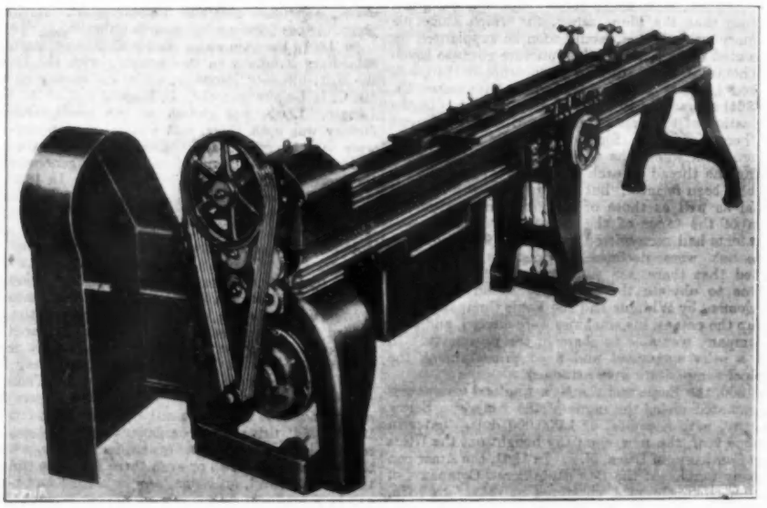


Fig. 1. Reaming Machine.

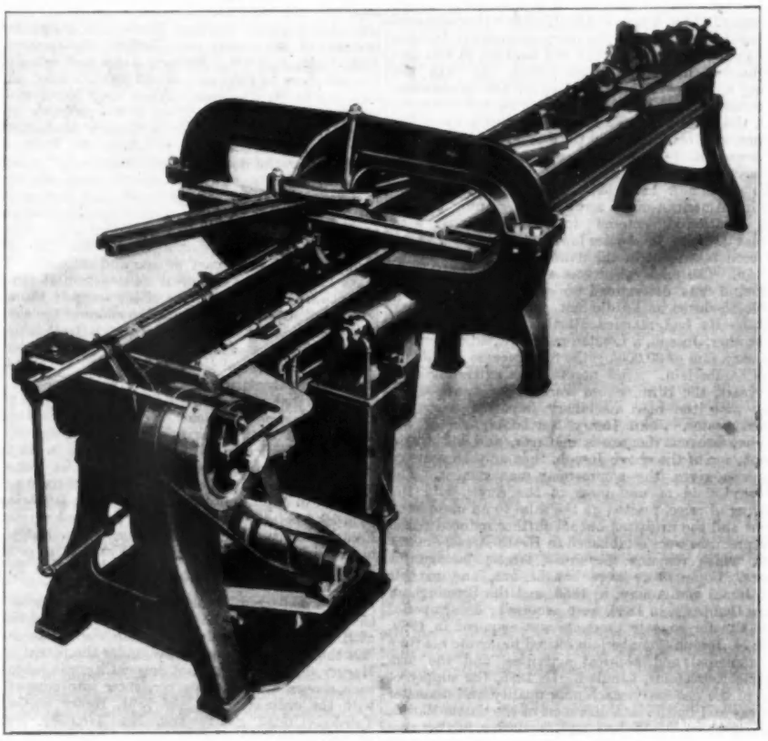


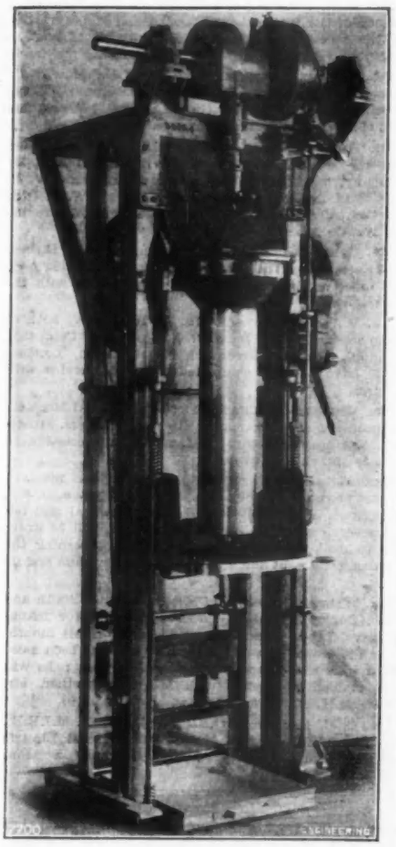
Fig. 2. Rifling Machine.

effecting the reversal of the saddle. The driving pulleys on the motor spindle are of different diameters in order to give the forward, or idle, stroke of the saddle a more rapid motion than the cutting stroke. The cutter is supplied with lubricant through its shank, as in the other machines, the supply pipe being readily identified on the left in Fig. 2.

The operations of drilling, reaming and rifling are followed by the enlargement of the bore to take the cartridge, an operation known as chambering and carried out on the fourth of the series of machines. The chambering machine deals with one barrel at a time and is not unlike a simple lathe in appearance. The work is rotated and the tool is fixed in a rotary direction, though it has longitudinal traverse. The barrel is gripped at the muzzle and in a chuck on the headstock spindle, which is carried in bronze bearings and provided with a range of 13 speeds by a variable-speed mechanism on the transmission gear, which is driven through a V-belt. The speed changes are made by a lever, operating over a graduated dial, on the front of the bed. The breech end of the barrel is supported in an adjustable steady rest. The tools are mounted in a turret, rotating on a horizontal axis and mounted on a sliding saddle. The feed is by a capstan handwheel. The face of the turret carries 8 quills arranged in a circle, each quill having a collet holding a floating reamer. The axis of the turret is not in line with the spindle, only the uppermost reamer occupying this position when in use.

PACKING MACHINE FOR POWDERED MATERIALS.

A NEWLY designed machine for packing various kinds of granular, semi-fine or flour-like materials into containers, is shown in the accompanying illustration. The machine, the Eureka packer, is made by Messrs. S. Howes Company, Incorporated, Silver Creek, New York, U.S.A. The material is fed into the receptacle by means of a vertical conveyor screw, the sack or container to be filled being supported on a platform which is lowered as filling proceeds. The feed screw, of course, is power driven, but the platform movement is effected by employing a counterweight for lifting and using a band-brake for the descent, the pressure of the packing process overcoming the counterweight resistance. The frame consists of steel joists and angles arc-welded together, with a single casting at the top to carry the driving gear. The platform seen behind the driving gear is to take a motor if a



self-contained Vee-belt drive is employed. When a belt drive is provided from another source, for example, from a countershaft, a flat belt is used and the platform is omitted. In the machine illustrated, no driving pulley is shown on the shaft.

The driving shaft is mounted in dust-proof Timken roller bearings. The housing in the centre covers machine-cut bevel-gears of hardened tool-steel, which transmit the drive to the feed screw. This housing is oil-tight. The feed-screw shaft has a radial thrust ball bearing and, where it passes into the upper end of the feed tube, is provided with a sleeve having adjustable packing glands, so that outward leakage of the material is prevented. The gear seen to the right of the housing is a clutch for engaging the bevel gear to the shaft. It is toggle-operated and engages and releases freely, while it is capable of transmitting the full driving power without slipping at the highest packing speed. The driving shaft speed is 250 r.p.m. The mouth of the hopper into which the material is fed opens behind the driving gear and has inside dimensions of 24 in. by 15 in. The tube which enters the container, and inside which the feed screw works, is attached to the bottom of the hopper in such a way that changes in size can be readily made.

When ready to commence packing, the operator slips the sack up the outside of the tube until it will go no farther, the platform being then in its lowest position, and not at the top of its stroke, as seen in the figure. The counterweight is at the top of its stroke and is held in this position by the band brake seen to the right. When the sack is adjusted, the operator depresses the pedal on the left side, an operation which releases the band brake and permits the counterweight to descend, with consequent elevation of the platform to its top position, in which position the bottom of the sack is supported. When it reaches the top position, the platform automatically engages the clutch on the feed drive, and delivery of the material commences immediately. The operator, by using the pedal, then controls the descent of the platform as the sack fills, the rate of descent determining the standard of density of the packed material. The control consists of regulating the pressure of the band brake on the shaft of the platform rope pulleys.

The filling continues until a predetermined point is reached, when the descending platform actuates a trip, which causes disengagement of the feed-drive clutch. The pedal is then depressed to its full extent, which movement takes off all band-brake pressure and the platform descends to its lowest position for removal of the filled sack. A pedal on the right re-sets the trip-gear for the next cycle. The various dogs on the clutch operating rod can be altered as required for different depths of filling. Springs on the platform guide rods prevent shock at each end of the platform stroke, and other buffer springs take the counterweight shock. The platform is formed with bars through which any spilled material falls to a tray at the bottom of the machine. Although not shown in the figure, the lower part of the machine is covered in at the back and sides to retain any spillage. The machine has a total height of 10 ft. and requires a floor space of about 4 ft. square.

NOTES ON NEW BOOKS.

Sixty-Year Index of A.S.M.E. Technical Papers, 1880-1939. New York: The American Society of Mechanical Engineers. [Price 3·75 dols.]

THE various ways in which papers presented before the American Society of Mechanical Engineers have been published during the 60 years of its existence have sometimes caused difficulty to searchers who have not appreciated the sequence of the *Transactions* (including the *Journal of Applied Mechanics*), the *Proceedings* (published from October, 1906, to June 1908), the *Journal* (September, 1908, to December, 1918) and *Mechanical Engineering* (published from 1919 to date). These difficulties are effectively resolved in the *Sixty-Year Index*, which provides a subject index and an author index to the papers, addresses and articles contained in all of these publications. The items in the subject index are chronologically arranged under 768 headings, with numerous cross-references. To keep the size of the volume within reasonable limits, no references are given to the more ephemeral matter such as reports of various functions, administrative affairs, and news items; nor to memorial notices of members, abstracted articles, book reviews, editorial comment, and individual contributions to the discussions on papers. For these it is still necessary to refer to the volume indexes. Some committee reports on standards and codes are included, but it is pointed out that these are not necessarily final, and should be supplemented by reference to the latest edition of the standard or code desired. To enhance the utility of the index, a paper may be listed under several headings where its subject matter touches upon more than one branch of engineering manufacture or application. While some of its limitations may be regretted, the general arrangement and the amount of information contained in the *Index* make it a reference work of outstanding value to all who are concerned with modern mechanical engineering developments.

Design of Concrete Structures. Fourth edition. By Professor L. C. Urquhart and Professor C. E. O'Rourke. London: McGraw-Hill Publishing Company, Limited. [Price 31*s*. 6*d*.]

THIS work is primarily intended to serve as a text-book for both elementary and advanced courses in engineering colleges. Its appearance in a fourth edition suggests that its merits for that purpose have been recognised, but it is likely that its success is not only due to its use by students, and that it has been found to appeal to a wider circle. Working from fundamentals, it deals with the design of all the more common types of concrete structure in such a way as to make it of direct value and application in the drawing office. It is not a general treatise on concrete construction and does not attempt to step out of its own field, except to give such information on aggregates, mixing, reinforcement, etc., as is necessary to enable a student properly to appreciate the various sections dealing with design. Successive chapters cover beams and slabs, columns, foundations, retaining walls, arches and beam and girder bridges. The text-book character of the volume is maintained by the addition of problems for class use at the end of various sections. This is a new feature in this edition. When reviewing the third edition, five years ago, we stated that one of the values of the book to a British engineer was that it formed a useful guide to the application of United States concrete codes. This still applies and has become of added importance as, following the completion of tests on columns by the American Concrete Institute, recommendations have been put forward for a revision of the appropriate sections in the Standard Building Code of the Institute. The results of this new work have been incorporated in the volume. A further modification in the new edition has been the collection of all tables and diagrams in an appendix at the end of the volume. The diagrams referred to are those containing curves connecting two quantities, which may be read off in order to ascertain design values; diagrams showing points of design and elucidating the calculation work appear in the appropriate places in the text. The collection of what may be called the reference material into a group will probably be found a convenience, particularly by those who use the book in practice. It may not be a similar advantage to an elementary student, but actually a student is hardly likely to make much use of such material until he has attained a fairly advanced stage.

Lessons in Arc Welding. Second edition. Cleveland, Ohio: Lincoln Electric Company. [Price 50 cents in U.S.A.; 75 cents elsewhere.]

THE publishers of this book are manufacturers of direct-current welding plant and a complete range of electrodes; and, like some other manufacturers, they maintain classes in their works for theoretical and practical instruction in the craft of electric welding. This book, set out in the form of 60 lessons, is the basis of their instruction course. In these circumstances, it is hardly surprising that it deals exclusively with their own products. Users of these products will find it an excellent catalogue of the various types of electrodes, giving information on tensile strength, yield point and elongation, and fatigue limit, and notes on resistance to abrasion or corrosion, suitable machine settings, the best method of use, and special functions for which the machines are designed. The initial lessons are of a general nature, on the regulation of voltage and current, the necessity for such regulation, etc., and are followed by a series dealing with the usual standard forms of joints in various positions, to be practised first with bare or lightly-coated electrodes, which are the more difficult to control. The student then practises with standard coated electrodes a series of exercises covering practice welds with each type, mild-steel, alloy-steel and non-ferrous. Instruction is given on the use of carbon electrodes for cutting, or for use with filler rods and powders which cannot be made up as electrodes. Finally, there is a series of test questions covering the field of the instructions. Naturally, the book is intended mainly for those interested in training, but there is much information on the practical side of welding, which may be of value even to those who regard themselves as proficient.

A Dictionary of Electrical Terms, including Electrical Communication. Fourth edition. By S. R. ROGET, M.A. London: Sir Isaac Pitman and Sons, Limited. [Price 12*s*. 6*d*. net.]

THE development of language, the introduction of new words, and changes which occur in the meanings of others necessitate that any dictionary shall be revised from time to time. This necessity is enhanced in the technical sphere, in which the development both of pure science and methods of application results in the appearance of a greater proportion of new words than is usual in the vocabulary of every-day usage. Revision required in technical dictionaries is in general due to new words rather than to alteration in the meaning of old, but cases do arise in which a term gradually acquires a new connotation. An example is furnished by the word "commutator." This originally meant any device for reversing the direction of a current, and is still used for some forms of reversing keys in low-current work. To the generality of electrical engineers, however, the word means the segmental drum by which current is collected from, or supplied to, the armature of a generator or motor. This is clearly explained in Roget's *Dictionary of Electrical Terms*, this particular definition well illustrating an important feature of the work. Actually, it is a compilation of explanations rather than of definitions in the strict sense. A series of definitions has been published by the International Electro-technical Commission; these are authoritative and represent the final court of appeal, but are not always expressed in a way comprehensible to anyone not closely familiar with the subject concerned. The fact that Roget, while giving the definitions, adds brief explanations, greatly adds to the value of his work.

This fourth edition contains much new matter, particularly in the field of radio-communication, in which the coiners of new terms have been particularly active. Much modernisation of phraseology has also been necessary, but, wisely, old-fashioned terms have not been discarded. It is right that expressions which may be met in technical literature, of which still important sections extend back over many years, should continue to be explained in a technical dictionary. No one, probably, now talks about a galvanic battery, but the term will be found, none the less, in many works that are still read. It has clearly been difficult to know what to include in this book and what to omit. As it covers the whole range of electrical science and practice, it is obvious that a large number of border-line terms must have come up for consideration. The electrical and mechanical side of a power house are so inextricably mixed that it is frequently impossible to say whether an item should be classified as electrical or mechanical. In general, a wise selection appears to have been exercised, although individual users may possibly consider that some missing terms should have been included and that some which appear should have been omitted. This, however, is a minor matter, and there is no doubt that this new edition will successfully carry on the useful work of its predecessors.

INSTITUTION ELECTIONS.

INSTITUTE OF TRANSPORT.

Member.—D. L. Clarke, O.B.E.; C. Grasemann; F. Pinto Teixeira; L. H. Short, M.C.

Associate Member.—F. W. Berkeley; J. L. Grumbridge; E. Higgins, Newcastle-upon-Tyne; C. L. Newbury; G. Smart, M.B.E.; R. Thomas.

ASSOCIATION OF CONSULTING ENGINEERS.

Member.—Major Eugene Guy Euston Beaumont, O.B.E., A.M.Inst.C.E., M.I.Mech.E., M.I.A.E., M.Inst.T., London, W.C.2; Hugh Bourne, M.I.E.E., M.I.H.V.E. (Albion T. Snell and Partners), Richmond, Surrey; John Duncan Campbell Couper, C.B.E., M.A. (Cantab.), M.Inst.C.E., M.I.Mech.E. (Livesey and Henderson), Reading, Berks.; Alfred Solomon Grunspan, A.C.G.I., B.Sc. (Eng.) (Lond.), M.Inst.C.E., M.I.Struct.E., London, S.W.1; Henry Charles Husband, B.Eng. (Sheff.), A.M.Inst.C.E. (Husband and Company), Sheffield, 10; Geoffrey Farrer Kennedy, M.A. (Eng.) (Cantab.), M.I.E.E. (Kennedy and Donkin), Weybridge, Surrey; Cecil Henry Pickworth, M.Inst.C.E., M.I.E.E. (Preece, Cardew and Rider), London, S.W.1; Leonard Copeland Watts, A.C.G.I., M.I.Mech.E., M.I.H.V.E. (J. Roger Preston and Partners), London, W.C.1; George Edward Windeler, M.I.Mech.E., M.I.Mar.E. (Rhodes and Windeler), Manchester.

INSTITUTION OF MECHANICAL ENGINEERS.

Graduate to Associate Member.—Eric Stanley Slater, B.Sc. (Leeds), Wakefield; Selborne Alfred Slade Smith, Bristol; Sydney Lester Spokes, B.Sc. (Belfast), Northwich; Harry Kerridge Sutcliffe, Runcorn; Bernard Joseph Swain, Alverstoke; Selwyn Whiteley, Huddersfield; Captain Philip Willmott, B.Sc. (Eng.) (Lond.), R.E., Lisburn; Colin Preston Witter, Chester.

Student to Associate Member.—Captain John Frederick Baker, R.A.O.C., Canterbury; Lieut. Clement Arthur Banks Wilkinson, R.A.O.C., Barnsley.

EXPORT OF ARGENTINE MINERALS.—The Argentine Inter-Ministerial Committee of Political Economy has decided that the exportation of certain minerals is only to be allowed to firms and persons granted special permits. The metals and minerals affected include mica, asbestos, fireclay, bismuth, borates, feldspar, fluorite, magnesium, manganese, ochres, potassium and its salts, soda, vanadium, wolfram, China clay and molybdenum.

THE IRON AND STEEL INSTITUTE.—The Council of the Iron and Steel Institute informs us that Mr. Walter S. Tower, President of the American Iron and Steel Institute, has been nominated an honorary member, and that Professor J. H. Andrew, D.Sc., and Mr. N. H. Rollason have been elected members of the Council. Further announcements are that the Hon. R. G. Lyttelton has been proposed as honorary treasurer, to take office at the annual general meeting of the Institute in 1942, and that, in pursuance of the policy of collaboration with local societies, the Council has invited the Presidents of the Sheffield Society of Engineers and Metallurgists and of the Sheffield Metallurgical Association to become honorary members of the Council during their periods of office. As announced on page 454, *ante*, Dr. A. McCance has been elected a vice-president of the Institute and Mr. J. Henderson has been proposed as President to take office at the annual general meeting in 1942.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publication Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 3*d.* including postage.

Colliery Wire Ropes.—Two recently-issued standard specifications, dealing with round-strand and flattened-strand steel wire ropes for colliery winding purposes (No. 236-1941) and with similar wire ropes for colliery haulage purposes (No. 330-1941), are revisions of what were originally four separate specifications, namely, Nos. 236, 237, 300 and 330. In the latter, the specifications for the round-strand and for the flattened strand wire ropes were issued as separate publications in each case. It was subsequently felt, however, that it would be more convenient to combine the two winding-rope specifications and the two haulage-rope specifications, and this has now been done. A number of modifications have been made in the two revisions. For example, the amount of pure zinc in the virgin spelter for the galvanising operations has been raised from 97 per cent. to 98·5 per cent., and it has also been specified that the core wires shall be of larger diameter than the cover wires. Further, slight modifications have been made to the clauses dealing with the tests by the manufacturer and the test by the purchaser, and the copper-sulphate test, included in the appendices has been revised to bring it into line with specification No. 443. In specification No. 236-1941 the acid electric process has been included as a process for the manufacture of the steel for the round-strand as well as for the flattened-strand wire rope. War-emergency revision slips have also been issued to both specifications to bring them into line with the agreements reached between the Steel Control and the manufacturers.

Mastic Asphalt for Roofing.—The preparation of a specification or specifications for asphalt for roofing was first suggested to the British Standards Institution in 1925, and, subsequently, a committee was set up to deal with this request. In 1931, after considerable investigation of the problem, it was agreed that a good deal more experimental work was necessary before a specification could be prepared. The need for a specification, however, has now become a matter of urgency, and the Institution was recently approached by two or three asphalt-producing firms suggesting that the immediate preparation of a specification was desirable. The work was therefore revived and war-emergency specification No. 988-1941 has just been published as a result. The publication constitutes the first of a series of specifications and it is hoped to issue additional specifications in due course. No. 988 deals with mastic-asphalt roofing, composed of limestone aggregate and either (*a*) asphaltic bitumen, or (*b*) equal proportions of asphaltic bitumen and refined Lake asphalt. Provision is made for the proportion of refined Lake asphalt to be varied by agreement between the architect or engineer and the asphalt contractor. It is specified, however, that this proportion shall not exceed 50 per cent. of the total asphaltic cement. It is understood that all the ingredients included in the specification are available at the present time and recommendations for the method of application of the mastic asphalt are included. Attention is drawn to the fact that unsuitable camouflage paints may cause considerable damage to asphalt roofs.

BOOKS RECEIVED.

University of Minnesota. Engineering Experiment Station. Bulletin No. 18. *Condensation of Moisture and Its Relation to Building Construction and Operation.* By PROFESSOR F. B. ROWLEY, PROFESSOR A. B. ALGREN and C. E. LUND. Minneapolis, Minnesota, U.S.A.: The Director, Engineering Experiment Station, University of Minnesota.

Some Notes on Occupational Skin Diseases. By ALEXANDER DUCKHAM. "Woodlawn," Page Heath-lane, Bickley, Kent: Alexander Duckham and Company, Limited.

Steel Sheet Piling. Scunthorpe, Lincolnshire: Appleby-Frodingham Steel Company, Limited. [Free to responsible applicants.]

United States Geological Survey. Bulletin No. 911. *Ore Deposits in the Vicinity of the London Fault of Colorado.* By Q. D. SINGEWALD and B. S. BUTLER. Washington: Superintendent of Documents. [Price 1·50 dols.]

Instituto de Pesquisas Tecnológicas de São Paulo. Bulletin No. 28. *Prova de Carga da Ponte de Aírosa Galvão da Companhia Paulista de Estradas de Ferro.* By P. F. ROCHA. São Paulo, Brazil: Instituto de Pesquisas Tecnológicas.

India. Forest Research Institute. Forest Bulletin No. 93. *Indian Timbers for Tool Helves and Handles.* By V. D. LIMAYE. Delhi: The Manager of Publications. [Price 5 annas or 6*d.*]

PERSONAL.

MR. A. E. SYLVESTER, general manager of the Gas Light and Coke Company, has been appointed Deputy Regional Fuel and Power Controller for the London Region.

MR. S. W. NELSON, of the Ministry of War Transport, has joined the service of the Ceylon Government to give advice on transport questions.

SIR JOHN H. M. GREENLY, K.C.M.G., C.B.E., has been elected a director of the Metropolitan Electric Supply Company, Limited, and its subsidiary companies.

MR. J. C. DAWES, Deputy Controller of Salvage, Ministry of Supply, since the commencement of hostilities, has now been appointed Controller of Salvage (Local Authorities).

MR. HUMPHREY MITCHELL, chairman of the Canadian National War-Labour Relations Board, has succeeded MR. N. A. MCLARTY as Minister of Labour of the Dominion, at Ottawa.

MR. R. E. PALMER has been elected a member of the Council of the Institution of Mining and Metallurgy, to fill the vacancy caused by the death of MAJOR H. STANDISH BALL.

DR. SYDNEY W. SMITH, C.B.E., A.R.S.M., F.I.C., honorary lecturer on metallurgy at the Imperial College of Science and Technology (Royal School of Mines), has been elected a Fellow of the Imperial College.

SIR HERBERT A. WALKER, K.C.B., a director and formerly general manager of the Southern Railway Company, has been elected chairman of Messrs. W. B. Dick and Company, Limited, and of Messrs. W. B. Dick and Company (Holdings), Limited, in succession to the late MR. CHARLES EDWARD DICK.

MR. CYRIL CLARKE, general manager to the Birkenhead Corporation Transport Department, is retiring from that office in February after 41 years' service with the Department.

MR. W. G. BAILEY and MR. E. H. NIXON, both of whom are directors of Messrs. G. A. Harvey and Company, (London), Limited, Greenwich Metal Works, London, S.E.7, have recently completed 50 years' service with the firm.

MR. GREVILLE RICHARD THURSFIELD, M.I.Mech.E., has been appointed managing director of Messrs. Sturtevant Engineering Company, Limited, in succession to the late MR. G. A. MOWER.

THE ALUMINIUM INFORMATION BUREAU has removed to new premises at 109, Jermyn-street, London, S.W.1. (Telephone, WHItehall 5411.) The technical and advisory services of the Bureau, as hitherto, will be available to deal with problems submitted concerning the working, treatment and application of aluminium and its alloys.

MR. WALTER T. SMITH, of Messrs. Thomas Smith and Sons (Rodley), Limited, crane and excavator manufacturers, Leeds, is retiring at the end of this month. He is the second son of the founder and has been associated with the Company for nearly 50 years; he was joint managing director with his elder brother, Mr. Frederick H. Smith, for 23 years.

DR. C. C. PATERSON, O.B.E., M.Inst.C.E., M.I.E.E., has joined the board of Messrs. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2.

SPECIAL NOTICE: GOODS FOR EXPORT.—The fact that goods made of raw materials in short supply, owing to war conditions, are advertised in ENGINEERING should not be taken as an indication that they are necessarily available for export.

THE INSTITUTE OF PETROLEUM.—The Council of the Institute of Petroleum offers a medal and prize, up to the value of 5*l.* in books or instruments, for the most meritorious essay submitted by a student member of the Institute on one of the following subjects:—Palæogeographical Conditions which have favoured Oil Accumulation; Interpretations of Geophysical Data in terms of Geology; Geochemical Methods of Prospecting; Metals for Drilling Equipment; Bottom Hole Testing Methods and their Interpretation; Syntheses from Petroleum Gases; Modern Techniques of Process Control in the Refinery; Recent Methods for the Chemical Refining of Gasoline; Mixed Solvent Refining; and the Production of Fuels alternative to (*a*) Gasoline or (*b*) Fuel Oil. Entries must be received by the Secretary not later than May 31, 1942. The maximum length of the essays is not specified, but, in general, they should be from 4,000 to 6,000 words in length. Entries are also invited for the Burgess Prize, worth up to 5*l.* in books, for an essay dealing with, either the history of the petroleum industry of any producing country (excluding the U.S.A.), or the price of crude oil. The conditions of entry for the Burgess Prize are the same as those for the Student's Medal and Prize. The offices of the Institute are at the University of Birmingham, Edgbaston, Birmingham, 15.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Activity prevails in the Scottish steel trade and although consumers are not pressing quite so much at the moment, production is being maintained at a high level. All the usual buyers are specifying freely and a large tonnage of material is being delivered against contracts. Shipbuilders and boilermakers are all busy on Government work and are likely to continue so for a long time, while structural engineers have many important contracts on hand and have been ordering considerable tonnages of sectional material. Special high-grade steel has again been in strong demand for munition work and the requirements of this class of steel are increasing week by week. The makers of steel sheets are particularly well employed on work of national importance. Prices are steady and are as follows:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—While the West of Scotland malleable-iron makers have quite a fair amount of work on hand they are not overburdened and could take on more contracts. Wrought-iron scrap is still in demand and steps are being taken to increase the supply by the removal of unwanted railings. The re-rollers of steel bars are not so busy at present and are able to keep abreast of all the current demands. The stocks of semies are still thoroughly satisfactory. The following are the present quotations:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—No change has taken place in the state of the Scottish iron trade during the past week and the output is maintained on a high level. The consumers of hematite and basic iron are still pressing for deliveries, and as steel scrap is not so plentiful, the steelmakers are requiring a larger tonnage of pig-iron, which is going straight into steel production. A fair business is going through in foundry grades of iron. To-day's market quotations are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

Holidays.—Christmas Day will, as usual, be a working-day in the iron and steel industries, and, on account of the war, the usual New Year holidays will be curtailed this year. The brief stoppage, however, will be welcomed by the staff and employees.

INDIAN ENGINEERING TRAINEES.—The first group of Indian engineering trainees sent to this country for a specialised workshop course, under a scheme formulated by Mr. Bevin, are doing well. A second group of trainees arrived recently, and a third group is being organised. As is well known, one of the main objects of the scheme is the acceleration of the production of munitions in India.

THE SPANISH CORK INDUSTRY.—It is estimated that the output of cork in Spain for the twelve months ending December 31, 1941, will be in the neighbourhood of 32,000 metric tons. This is about 50 per cent. of the yield for a normal year. It is stated that about 40 per cent. of Spain's exports of cork and cork products are consigned to Germany, Italy, and German-occupied countries in Europe.

DAM WORKS IN INDIA AND AFGHANISTAN.—It is stated in *Indian Engineering* that the Afghan Government is contemplating the construction of a large dam at Farahrud in Western Afghanistan. The dam would check the ravages wrought by floods and would also be used for storing water for irrigation purposes. Another interesting scheme is that which has been prepared for utilising the water stored at the Nizamsagar Dam, the largest in the State of Hyderabad for the generation of hydro-electric power.

MOTOR FIRE LADDER FOR GLASGOW FIRE BRIGADE.—The Glasgow City Fire Brigade recently placed in service a motor turntable fire ladder. The ladder and ladder mechanism were supplied by Messrs. Merryweather and Sons, Limited, Greenwich Road, London, S.E.10, and mounted by Messrs. Leyland Motors, Limited, Leyland, Lancashire, on one of their chassis. The ladder is in four sections, capable of extension to a height of 100 ft. from ground level and is entirely of welded steel construction. Four jacking-up screws are carried on swinging members and provide a rigid base under the chassis framing when the ladder is in use.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Business is usually very quiet towards the end of December but in the present circumstances buyers of iron and steel are anxious to place orders as soon as delivery licences are obtained, and considerable contracts have been made for supply over the first quarter of 1942. The reduction of imports from the United States may be less severe than was anticipated, but the increased demand for munitions necessitates full activity at the works.

Cleveland Iron Trade.—There is no shortage of foundry pig, although the supply of local brands is still meagre; prospects of a material improvement in the light intermittent make of Cleveland pig are remote. Regular deliveries of foundry iron from the Midlands and other producing areas, however, are ample for all purposes. Consumption is steadily increasing, notwithstanding the extensive use of scrap. The fixed prices of Cleveland pig are based on No. 3 description at 128*s.* delivered within the Tees-side zone.

Basic Iron.—Producers of basic iron do not feel justified in providing any tonnage for the market but are maintaining output at a level that covers the heavy requirements of their own steelworks and enables small additions to be made to stocks. The official figure for basic iron remains at 120*s.* 6*d.*

Hematite.—Conditions in the hematite branch of trade, while still stringent, are slowly improving. Strict adherence to the control of distribution regulations, however, is still necessary, but the restricted supply enables regular deliveries to be made for essential requirements. The use of substitutes is extending satisfactorily. Refined iron, in particular, is passing into consumption, instead of hematite, in increasing quantities, and use is also being made of suitable scrap to a large extent. The stabilised values of hematite remain at the equivalent of No. 1 grade of iron at 138*s.* 6*d.* delivered to North of England buyers.

Foreign Ore.—Users of most kinds of foreign ore are well placed for supplies, but consumers of descriptions needed for hematite production still find deliveries somewhat inadequate.

Coke.—Durham blast furnace coke is plentiful, but the recognised market values are firm at the level of good medium qualities at 36*s.* 9*d.* f.o.r.

Manufactured Iron and Steel.—Stocks of semi-finished iron and steel are maintained at a satisfactorily high level; increased deliveries of local products largely compensate for the loss of imports. Finished-iron manufacturers have numerous orders, mostly for heavy commodities; they could, however, take more orders for light commodities. Munitions production has increased the demand for special alloy steels still further, and has necessitated prompt measures for the enlargement of outputs. All steel-producing plants, with the exception of mills rolling structural material, are very busily employed. The large distribution of sheets is sufficient for the requirements of customers; specifications for shipbuilding requisites continue to receive particular attention.

Scrap.—Users of iron and steel scrap are well bought but are still anxious to place orders for heavy material.

HEATING-BOILER AND RADIATOR MANUFACTURERS' ASSOCIATION.—The Cast-Iron Heating-Boiler and Radiator Manufacturers' Association, Limited, has been registered as a company limited by guarantee, without share capital. As its name implies its main purpose is to protect and promote the interests of manufacturers of cast-iron boilers and radiators. The subscribers to the memorandum of association include Messrs. Beeston Boiler Company, Limited, Beeston, Notts.; Messrs. Crane, Limited, London, E.C.2; Messrs. Hartley and Sugden, Limited, Halifax; Messrs. Ideal Boilers and Radiators, Limited, London, W.1; and Messrs. Lumbeys, Limited, Halifax.

TRAINING OF ACCIDENT-PREVENTION ORGANISERS.—The first training course for industrial accident-prevention organisers, arranged by the Royal Society for the Prevention of Accidents on behalf of the Factory Department of the Ministry of Labour and National Service, is stated to have been so successful that a second course is being held at Balliol College, Oxford, from January 2-13, 1942. The syllabus covers every aspect of industrial-accident prevention and upwards of 20 lecturers will take part. Particular efforts are to be directed to giving trainees a solid grounding in the now extensive technology of the subject, as well as in organisation, and in the law relating to accident prevention. The course is residential and about 50 trainees, nominated by their employers, will be accommodated. Programmes and syllabuses are obtainable on application to the Society, 52, Grosvenor-gardens, London, S.W.1, or 426, Strand, Cheltenham, Gloucestershire.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Meter and Instrument Section:* Friday, January 2, 4 p.m., Savoy-place, Victoria-embankment, W.C.2. "The Electrostatic Voltmeter as a D.C./A.C. Transfer Instrument," by Messrs. R. S. J. Spilsbury and A. Felton. *Wireless Section:* Wednesday, January 7, 4 p.m., Savoy-place, Victoria-embankment, W.C.2. "Aerial Characteristics," by Mr. N. Wells. *North Midland Students' Section:* Saturday, January 10, 2.30 p.m., The Hotel Metropole, King-street, Leeds. Address by the chairman of the North Midland Centre, Mr. F. Gurney.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, January 3, 2.30 p.m., 39, Victoria-street, Westminster, London, S.W.1. Informal Meeting. Lecturette: "Some Technical Terms," by Mr. J. Foster Petree.

INSTITUTION OF CIVIL ENGINEERS.—*North-Western Association:* Saturday, January 3, 2.30 p.m., The Engineers' Club, Albert-square, Manchester. Film Display: "The Failure of the Tacoma Narrows Bridge." [To be preceded by luncheon at 1.15 p.m.]

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 9, 2.30 p.m., Storey's-gate, St. James's Park, Westminster, S.W.1. Extra General Meeting, in conjunction with the Steam Group. "The Utilisation of Wood Refuse for Steam Raising," by Mr. R. B. Gillham.

STOKE-ON-TRENT ASSOCIATION OF ENGINEERS.—Saturday, January 10, 6 p.m., at Messrs. Robert Hyde and Son, Limited, Stoke-on-Trent. Discussion on "Arc Welding."

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—All the large steel and engineering works shut down to-night for one day's holiday. Operations will be in full swing again on Friday, with the maintenance staff working on Christmas Day to carry out urgent repairs to machines. Inquiries show that Sheffield's war effort is increasing, and that production is larger than it was a year ago. Suppliers of raw and semi-finished materials have more furnaces operating. The demand has increased considerably during the year, and producers are to be congratulated on the way in which they are supplying the requirements of their customers. All types of semi-finished steels are in strong request; forward buying is very difficult to arrange as outputs are mortgaged for months ahead. The scrap positions is quite satisfactory; a larger quantity is now available from various sources. Rolling mills, forges, and press shops are all operating at full capacity. There is a brisk demand for structural steel, including angles, joists, and bars. Wire ropes, and all classes of springs, especially those used in connection with railway rolling stock, are in strong request. The position of the heavy-machinery and engineering branches has undergone no material change, but mining equipment is in improved demand. The shortage of wooden pit props has resulted in more steel being used in the pits for supporting roofs. Electrical plant is a progressive line. Foundries, which were greatly extended in pre-war years, are now turning out record tonnages of castings of various sizes, and weights. Considerable activity is being maintained in the production of agricultural steel, machinery, and machinery parts. The special-steel branches are accounting for record outputs. The production of oil-hardened die steel is increasing and there is a heavy demand for alloy and carbon tool steels. There is also an active market in high-speed steel, mining-drill steel, manganese steel, and magnet steel.

South Yorkshire Coal Trade.—Coalowners are urging miners to take one day holiday, but at some pits the stoppage may extend to two, or possibly three, days. The demand for industrial fuel has been well maintained. Slacks and smalls are moving freely, and the house coal market is active; supplies generally are good.

TRANS-CONTINENTAL AIR SERVICE IN SOUTH AMERICA.—What is described as the first trans-continental air service in South America was recently inaugurated. The service, which is between Lima, Peru, and Rio de Janeiro, Brazil, is a weekly one in both directions, commencing on Wednesdays from each terminus and ending at the opposite terminus on the following Friday. The route and stopping places are the same in each direction. From west to east, after leaving Lima, the aircraft lands at Arequipa, Oruro, Cochabamba and Santa Cruz, Bolivia, during the first day's journey. On the second day, after leaving Santa Cruz, the aeroplane lands at Puerto Suarez and reaches the Brazilian frontier at Corumbá. Starting out from Corumbá on the third day, the aircraft lands at Campo Grande, Tres Lagoas and São Paulo, finally arriving at Rio de Janeiro.

CONTINENTAL DIVIDE TUNNEL, COLORADO, U.S.A.

FIG. 1. BLOWER INSTALLED IN RECESS IN TUNNEL WALL.

VENTILATING SYSTEM FOR CONTINENTAL DIVIDE TUNNEL.

THE Continental Divide tunnel, 13 miles long, and estimated to cost 50 million dols., is being driven through the Continental Divide between Estes Park and Grand Lake, Colorado, to bring water from the western side of the range to the eastern side for the purpose of irrigation. In addition, a large output of electrical power will be generated by plants disposed along the line of the tunnel. The undertaking is under the direction of the United States Bureau of Reclamation. The boring of the eastern end of the tunnel is being carried out by Messrs. The S.S. Magoffin Company, of Estes Park, who have recently installed there a ventilating system which is claimed to be the most effective yet devised.

The plant consists of heavy-duty blowers, driven through V-belts by General Electric motors of 100 horse-power each, taking current at 2,200 volts and provided with full-voltage automatic reversing control gear, also of General Electric make. As the work progresses, the blowers are being installed in recesses cut in the walls, as shown in Fig. 1, above, at intervals of 9,000 ft. along the tunnel. All the units are controlled from the compressor house, at the entrance to the tunnel, the method of operation being as follows. After holes have been drilled in the heading, the fans are stopped while the blasting charges are inserted. The shots are fired electrically and, immediately afterwards, the operator in the compressor house is notified by telephone to restart the fans, to exhaust the bad air from the tunnel. Twenty seconds after the blower nearest to the heading comes into action, the second blower starts, and so on down the tunnel. These intervals allow sufficient time for the air to reach each blower in turn, thereby eliminating the possibility of creating a partial vacuum in the duct. The blowers exhaust for about 20 minutes, sucking all the smoke and gases from the heading, and are then reversed, to blow fresh air into the tunnel. After the "reverse" push-button is pressed, there is a delay of one minute before the motor in the portal of the tunnel begins to run in the opposite direction; this is provided to allow the motor time to come to rest. Twenty seconds later, the second blower picks up the load, and the remaining motors come in similarly, at 20-second intervals. Fresh air is blown into the tunnel for about 30 minutes, and then the blowers are again reversed. Exhausting continues until the men in the heading are ready to fire the next charges, when the ventilating plant is shut down and the cycle of operations is repeated.

The system requires only one pipe to supply fresh air and exhaust foul air, and thus is much more economical than a double blower system. Blowing and exhausting are controlled in accordance with the outside temperature, to avoid the creation of fog in the tunnel; in this way, the working heading, and the whole length of the tunnel, can be kept entirely free from fog and smoke. The second illustration, Fig. 2, above, is from a photograph taken 9,000 ft. from the heading, and shows the clearness of the tunnel atmosphere. By the installation of this ventilating system, it is stated, the time required for each drilling cycle has been reduced by 20 minutes; the men working in the heading can return to their posts immediately after the shots have been fired, instead of waiting for the smoke to clear. As a result, the average rate of advance has been increased by 6 ft. a day.

FIG. 2. VIEW IN TUNNEL, 9,000 FT. FROM HEADING.

THE ROYAL HELLENIC NAVY.—The Greek Fleet arrived at Alexandria in April, 1941, and, acting in concert with the British Mediterranean Fleet, has become a valuable fighting unit in the Allied cause. A report received by the Admiralty from the Commander-in-Chief, Mediterranean, states that both submarines and destroyers of the Royal Hellenic Navy have taken their full share of patrols. The submarines have recently achieved successes against the enemy, and destroyers have done valuable work on escort duty. Three destroyers have each steamed more than 7,000 miles in the last four months.

LIBRARY OF THE INSTITUTION OF MINING AND METALLURGY.—As already announced in our columns, the library of the Institution of Mining and Metallurgy has been transferred to the Mill Close Mine, Darley Dale, Matlock, Derbyshire. We now learn that the Council of the Institution has decided that the outward postage on books sent on loan, shall be paid by the Institution so long as the library is outside London. We note with interest that the Council has recently acquired from Mr. L. B. Williams, M.Inst.M.M., a collection of old mining books, chiefly dealing with Derbyshire, some of the books being extremely rare. It is intended to publish a full list of these volumes in a future issue of the *Bulletin* of the Institution.

ENGINEERING.

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We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730 and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, DECEMBER 26, 1941.

VOL. 152. No. 3963.

AXIAL VIBRATION OF DIESEL-ENGINE CRANKSHAFTS.

MANY of the troublesome effects of vibration in internal-combusion engines, from which steam engines are almost completely immune, can be traced to the large range of pressure within the cylinder and the characteristic working cycle, in which only one stroke in four is a power stroke. These factors, in combination, give rise to rapid rates of change of piston loading, relatively high speeds of rotation, multi-cylinder engines, and crankshafts of flexible form. Such a machine is inherently prone to vibrations, both because the forcing agencies are strong in relation to the inertia and damping resistance of the structural components of the engine, and also because the impressed frequencies, due to multi-cylinder operation at high speeds, rise within the range of natural frequency of the engine components and so promote resonance. Torsional vibrations of the crankshaft, which are an obviously important consequence of these factors, have been extensively studied in this country and abroad with such success that torsional fatigue is now largely avoidable, either in the original design or by corrective devices.

The comparative rarity of failure by torsion throws into greater prominence the occasional occurrence of crankshaft fractures exhibiting symptoms characteristic of bending fatigue, and justifies the investigation of the several modes of vibration that cause fluctuating tensile stress. Although this type of fracture usually originates at situations, such as the junctions between crank webs and pins or journals, where stress concentration is an important contributory factor, the probability of cyclic stressing above the fatigue limit, arising from resonant vibration, often amounts almost to certainty and must never be overlooked. Conditions can exist, of course, such that more or less straightforward bending of the crankshaft can take place to an excessive extent under the normal working of the engine; so that unduly worn bearings, imperfect alignment and inadequate rigidity of bedplate or crankcase are contingencies to be avoided. In this connection, the mounting of Diesel engines in road and rail vehicles upon supports that are so flexible and so disposed as to prevent strains in the vehicle structure from being transmitted to the case and shaft of the engine is important.

Even if no such defects are present, however, it is not difficult to visualise that axial crankshaft vibrations can occur, either directly from cyclic forces applied to the cranks, or indirectly as a consequence of interaction between torsional and axial strains. Whether one or other of these predisposing causes predominates is a question of considerable interest which the few relevant investigations* of recent years have failed to settle conclusively. The experiments which form the substance of Mr. Ralph Poole's paper on the axial vibration of Diesel-engine crankshafts, delivered before the Institution of Mechanical Engineers on December 19, were undertaken with this moot point prominently in mind and have fulfilled their main objective by establishing that, under favourable conditions of speed, some engines are subject to a very marked increase in axial vibration of a magnitude consistent with true axial resonance. Mr. Poole's conclusions are based on records made with highly sensitive vibrometers upon six Diesel engines of different makes, supplemented by a mathematical analysis of the natural frequency of axial vibration, and substantially confirmed by an experimental determination of the resonant frequencies of a number of crankshafts having a wide range of proportions.

One of the engines under trial—a single-cylinder Diesel with a thrust block and flywheel at one end of the crankshaft—exhibited, at about 200 r.p.m., a maximum cyclic change of 0·025 in. in the length of the shaft. Simultaneous vibrations of each end contributed to the total amplitude; but, while the natural frequency of the flywheel itself was apparent, the thrust block, acting as a semi-rigid support, restricted the movement at that end to a small proportion of the amplitude at the free end. The next engine to be tested, a six-cylinder Diesel rigidly connected to a generator, was affected by a marked increase of axial vibration with load, and showed clear indications of resonance at both the free ends of the shaft. The relation between axial and torsional resonance was exemplified by enhanced axial vibration when the engine ran at a torsional critical speed, the immediate linkage between the two modes being explained by the author as due to "spiralling" of the crankshaft. At another rotational speed, however, critical axial vibration was manifest independently of any torsional oscillation. The latter phenomenon was again observed in trials of another six-cylinder engine, in this case flexibly connected to an electric generator through a coupling designed as a detuner to restrain critical torsional vibrations.

Another type of axial vibration was recorded in the case of a short-stroke four-cylinder Diesel engine. Regular well-defined axial amplitude was present in the crankshaft at all speeds, increasing in magnitude as the load was raised from 180 h.p. to 450 h.p., but showing no sign of resonance within the range of speed up to 500 r.p.m. In this example, the natural frequency of the crankshaft was high by reason of the thrust block being midway along the engine, thus effectively dividing the shaft into two parts with a node between them; and it would be unsafe to conclude that, had the same design of crankshaft been operated at higher speeds, axial resonance would not have occurred. One of the other engines tested, for instance, exhibited critical axial vibration of six oscillations per cycle at 1,600 r.p.m., corresponding to a natural frequency of 4,800 per minute, with no related torsional resonance. This engine was of the road-traction type, having six cylinders, with a thrust collar at the coupling end. On the other hand, another road-traction type six-cylinder engine fitted with a torsional damper exhibited critical torsional vibrations accompanied by pronounced increases in axial vibration.

The results of these varied trials establish the fact of axial vibration beyond dispute, and point to the need for the fullest possible analysis of the

* See Poole, *Proc. I. Mech. E.*, vol. 131, page 470 (1935), and Dorey, *Trans. N.E.C.Inst.*, vol. 55, page 203 (1938-9).

complex inter-relation of factors upon which a dangerous degree of vibration depends. To this primary stage in the solution of the problem, Mr. Poole's paper makes two further valuable contributions. In the first place, he derives mathematical formulæ for the natural frequency of axial vibration in terms of the dimensions, inertias and rigidities of the crankshaft. He restricts this study to first-degree vibrations, with the node at the thrust bearing, since no evidence of vibration higher than the first degree was forthcoming from the six engines examined experimentally. Among the chief difficulties encountered are the estimation of "equivalent" dimensions for parts of a crankshaft—such as the webs and the journals—which have very different cross-sectional shapes; and the complications introduced by the fact that, in the general case, the neutral axis is not a straight line normal to the plane of the crank. The stiffness characteristic therefore involves an empirical factor which Mr. Poole has determined, in a number of typical cases, by measuring the deflections of crankshafts axially loaded in a static testing machine. Similar results of value to engine builders were obtained from stiffness measurements of a Diesel-engine crankcase, which was found to be nearly twenty times as stiff as the crankshaft (an isolated example), and therefore unlikely to reduce appreciably the natural frequency of axial vibration of the shaft, though equally unlikely to restrain the crankshaft journals from bending to an extent represented by the bearing clearances.

Mr. Poole's next step was to test his theory by determining the natural frequencies of crankshaft vibration experimentally. With this object, the shaft under examination was carried vertically from a very rigid support, and axial vibrations were excited in it by an electromagnet energised from a source of frequency variable up to 1,000 cycles per second. As a means of practically measuring critical frequencies, the method was found to be eminently suitable and free from serious difficulties in application. Tests on various types of crankshaft assemblies revealed that a flywheel tends to produce a more definite axial movement of the shaft, restricting radial movement to such an extent that the end bearing in an engine could exert no appreciable influence on the axial stiffness of the crankshaft. On the other hand, the stiffness of the flywheel, as a diaphragm, can markedly affect the natural frequency of axial vibration of the whole assembly, and calculation of frequency must take account of the vibration of the flywheel, which, in turn, is affected by the bending of the end crank. It is evident, further, from the unsymmetrical features of typical crankshafts, that axial vibrations will generally be associated with radial or bending vibrations, of which the severity and frequency must be closely affected by the amount and distribution of mass in the flywheel. One of Mr. Poole's tests showed, indeed, that, at two critical frequencies between 90 cycles and 100 cycles per second, the amplitudes of radial vibration exceeded those in the axial direction when the flywheel was actually removed. Another, somewhat unexpected, feature of interest was that, under certain critical conditions, the maximum axial vibration occurred, not at the free end, but at an intermediate position along the shaft.

Two important inferences that follow from these forced vibration tests are that, if a crankshaft is fitted with a flywheel or coupling, the complete assembly needs to be studied as a whole; and that ample justification exists for comprehensive exploration of axial vibration phenomena, both as general research and as an aid to the development of particular designs. Underlying the whole of Mr. Poole's work is, firstly, the presumption that fatiguing stresses, imposed by cyclic loading and enhanced by resonant vibration, are the proper criterion of design, and, secondly, that the axial vibration problem is influenced by so many variables, and its mathematical treatment is consequently so complex and uncertain, that for some time to come the experimental approach offers by far the most hopeful prospect. The large question of the stresses caused by axial and bending vibrations, with the complications introduced by stress-concentrating features inherent in the shape of a multi-crank shaft, has so far been barely touched. In this and other aspects of vibration study, the need is urgent for experimental results that will indicate the most important directions of fundamental research and serve as a check upon the accuracy of theories.

Since knowledge of axial vibration is at present too incomplete to indicate much more than certain principles of design, it seems reasonable to consider how far the electromagnetic method of testing could be used to supplement the procedure commonly adopted during the development of new types of Diesel engines. Would it not be feasible for the manufacture and testing of a crankshaft to be undertaken as a matter of routine at an early stage in the design? The test is non-destructive, and, while it may present some difficulties, it offers potential advantages too valuable to be ignored; notably, a degree of confidence that purely mathematical design could hardly inspire, and an abundant source of factual information. Determinations of stiffness and vibration characteristics upon the crankshaft assembly must, of course, be regarded as no more than provisional objectives, the final test being the performance of the shaft in the finished engine. There is scope, therefore, for more advanced forms of test than those which Mr. Poole has described, in order to ascertain, for example, effects due to the inertia of the connecting rods and pistons, to the constraint and damping of bearings, and to the order of firing in multi-cylinder engines. Finally, Mr. Poole's conclusions—perhaps the more because they are, in many respects, tentative—point to the need for more widespread records of axial vibration under service conditions. Owing to lapse of time since manufacture, the multiplicity of possible causes, the destruction of evidence, or even mere ignorance, fatigue failure due to vibration is never easy to diagnose with certainty, but its consequences may be fatal and are always costly.

EXAMINATION BY THESIS

THE amended regulations governing the associate-membership examination of the Institute of Transport, which were the subject of an editorial Note on page 473 of our issue of December 12, add one more to the number of examining bodies which are prepared to accept a "thesis" in lieu of set papers of examination questions; and there is not the least doubt that the Council of the Institute, in their endeavour to circumvent the examination bogey, which is such an obstacle to many men of proved experience who have lost the habit of acquiring book-knowledge and reproducing it accurately and expeditiously on paper, will have erected another, even more fearsome, in the path of many otherwise eligible candidates. This may seem to be an over-statement; but we are convinced that it is not, having ample first-hand evidence to the contrary. Emerson may have indulged in exaggeration when he declared that "fear always springs from ignorance," but it is undeniable that many men who, on applying for corporate membership of technical institutions, have been adjudged "associate-member, subject to thesis," at once have abandoned all thought of competing for the desired distinction, for no better reason than ignorance of the exact nature of the test that was required of them.

Much of this hesitation, we believe, is traceable to the use of the term "thesis," an expression which has so many interpretations that, in the absence of positive direction, it is often difficult for the candidate to know which is applicable. The kind of thesis that is demanded as qualification for a university doctorate must obviously be different from that required, say, for the Durham Bursary of the Junior Institution of Engineers (an award, incidentally, which has never attracted as much attention as it deserves from young engineers), for which the upper limit of age at entry is the 23rd birthday. A thesis that will satisfy the examiners for associate-membership of the Institution of Mechanical Engineers will rank, it is evident, somewhere between the two. The thesis for a doctorate is usually required to make some definite addition to existing knowledge of its subject, whatever that may be; it may represent the fruits of years of individual work, and approach in bulk to the contents of a substantial text-book.

The theses required by the new regulations of the Institute of Transport, like those submitted to some other examining bodies, and for the Durham Bursary, are to be written in the candidates' own time; it is sufficient that they shall be accompanied by declarations from responsible persons that they are the candidates' own work, and that they shall reach a certain professional and literary standard, usually expressed in rather vague terms because it is so seldom possible to define the standard with any exactitude. The Institute of Transport rules are that candidates (who must be at least 35 years of age and otherwise suitably qualified for associate-membership) may be permitted, on application, to present a thesis, and must submit the proposed title and a synopsis with the application. The thesis "must show practical and theoretical knowledge of transport and should be a record of original thought or research." The requirements regarding the style and technical character of a Durham Bursary thesis are relatively indeterminate—no doubt, purposely so; it is sufficient that it shall be "written in the English language, on some engineering, technical or scientific subject selected by the candidate."

Theses for associate-membership of the Institution of Mechanical Engineers are in a quite different category and are subject to a much more detailed specification; though, even so, we know that some candidates have found difficulty in visualising the precise requirements. They are to be written under examination conditions—that is, under supervision, without reference to notes or books, and within a time limit of three hours. The object of the thesis, it is explained, is "to give the candidate an opportunity of demonstrating . . . his theoretical and practical knowledge of some branch of mechanical engineering and the underlying scientific principles. Descriptions of machines, or plant, or work done by the candidate, are generally suitable as subjects," provided that they are accompanied by "criticisms or suggestions for improvements in methods or materials." Wherever possible, a thesis should be illustrated by sketches. The composition of such a thesis, it will be seen, is subject to very definite physical limitations; he is a clear thinker and a fluent writer who can turn out a presentable manuscript of as much as 1,200 words (approximately the length of this article) within three hours, even though the subject has been agreed upon beforehand; and if the accompanying sketches are at all detailed, he may find that 1,000 words, "logically arranged under headings and paragraphs" as the rules direct, tax his capabilities to the utmost. Limitations like these are often overlooked.

Rightly applied, the thesis is often a more dependable test than an examination paper, and its use might be extended with advantage; but if this is to be done, it is very desirable that the clearest possible guidance should be afforded to intending entrants. Examination candidates can usually obtain the papers set in earlier examinations; thus they can be reasonably certain of the type of question likely to be set, and the standard that is expected of them—knowledge which goes a long way towards instilling the confidence that is so great an asset in the examination room. By comparison, the writer of a thesis too often gropes in the dark. One examining body may require, in fact, little more than a reasonably well-written essay; another is satisfied with a dissertation of the general character of signed articles that would be acceptable for publication in a technical journal; a third demands a study which, in length and erudition, would qualify as a paper to be read before one of the major engineering institutions; yet each will describe the required test as a "thesis," and, by treating the theses submitted as "confidential documents," deprives intending candidates of the guidance that the "examination wallah" enjoys. A little more exactitude in definition, and the occasional publication of a successful thesis, would not only encourage more candidates to come forward, but we believe would result in a more satisfactory average of performance than is the general experience of examiners of these scripts.

NOTES.

THE JUNIOR INSTITUTION OF ENGINEERS.

ON Saturday, December 13, the Rt. Hon. Lord Sempill, A.F.C., was inducted as President of the Junior Institution of Engineers by his predecessor, the Rt. Hon. Viscount Falmouth. Lord Sempill began his presidential address by paying tribute to Lord Falmouth's valuable work for engineering and the national effort as vice-chairman of the Engineering and Scientific Advisory Committees, of which Lord Hankey is chairman. Continuing, Lord Sempill recalled that he had been a member of the Junior Institution of Engineers for more than a quarter of a century, during which time it had played a significant part in the education of the technical men who would have so much to do in remaking and controlling the world of to-morrow. He stressed the importance of an apprenticeship in an engineering works, and said that the experience of production to be gained there was of greater value, in his opinion, than the kind of training which began in a university, where it was generally difficult to combine sufficient practical engineering training with the necessary academic instruction. Engineering education, both in universities and in most technical colleges, needed revision to bring it into closer relation with the needs of to-day. Too much emphasis was laid on academic qualifications and not enough on the practical side of manufacture and organisation. The late Lord Austin had said that the immediate need was for men who were 50 per cent. engineers and 50 per cent. organisers. That, Lord Sempill considered, was what a production engineer should be, and the educational system should be modified to that end. A start had been made in this direction by the introduction, this year, of a Higher National Certificate in Production Engineering. He was proud to have been associated with this move, in conjunction with Lord Nuffield. Far too many young men of ability had devoted themselves to design merely because they sought an engineering degree or certificate. Invention and design were fundamental, but production was of vital importance at present. The real problem was to design for production with the minimum expenditure of material and man-hours. The training of those who had to control production was, therefore, of the utmost importance, especially in view of the difficulties involved in the introduction into industry of masses of unskilled labour, with no experience of technicalities. These large numbers of unskilled people had to be made technically aware of the aspects of their particular operations. This could best be done by means of lectures and demonstrations, but skilled men could ill be spared from actual productive work for this purpose, and it had been necessary to develop new methods, which had proved very successful, for the instruction of employees who possessed no technical experience.

BRITISH COAL UTILISATION RESEARCH ASSOCIATION.

The fourth annual general meeting of the British Coal Utilisation Research Association was held on December 10 at the Association's experimental station at West Brompton, London, and the members had an opportunity of seeing the results of research and of witnessing investigations in progress. After inspecting a number of vehicles, ranging from private cars to three-ton and five-ton lorries, fitted with gas producers developed by the Association, some built on to the chassis of the vehicle and others mounted on trailers, the members made a tour of the experimental station, in which research work on both industrial and domestic problems is conducted. Sir Evan Williams then delivered his presidential address, an abstract from which is printed on page 514. The address dealt with the progress of the Association's work during the past year, and, at the outset, Sir Evan stated that the accounts showed expansion both of revenue and of expenditure, which were an indication of the increasing demands for the services of the Association. During 1940, the capital expenditure on the experimental station had been completed; and this had been done notwithstanding the increased difficulties and costs due to the outbreak of the war, within the total of 20,000*l.* approved by the Council in 1938. The work of the station had been continued right through the "Battle of London" with only one interruption of 24 hours. After the delivery of the presidential address, the Council of the Association for 1942 was elected. The members nominated by the British Colliery Owners' Research Association, and elected, were Messrs. M. K. Burrows, R. Clive, W. J. Drummond, J. H. B. Forster, Major T. M. Hudspeth, Mr. C. H. Heathcote, Major H. Mitcheson, and Messrs. J. S. Turner, I. R. Williams, J. R. Wilson, and T. E. B. Young. The members elected to represent the Combustion Appliance Makers' Association (Solid Fuel) were Mr. N. M. Bell, Sir John Greenly, K.C.M.G., C.B.E., and Messrs. H. Lindars, S. McEwen, J. A. Reavell, W. Rennie, E. W. Robey, C. L. Scott, F. G. Smith, G. A. Ure, and N. Crighton. The co-opted members of the Council are Mr. J. Charrington, Dr. E. S. Grumell, Mr. J. R. Hopper, Sir William Larke, K.B.E., and Mr. W. A. Lee, C.B.E. Mr. A. L. Hetherington, C.B.E., and Dr. F. S. Sinnatt, C.B., C.B.E., F.R.S., continue to represent the Department of Scientific and Industrial Research.

LOCOMOTIVE BALANCING, AND HAMMER-BLOW EFFECTS.

A JOINT meeting of the Institution of Civil Engineers and the Institution of Mechanical Engineers was held on Tuesday, December 16, at Storey's-gate, St. James's Park, London, S.W.1. The chair was occupied by Professor C. E. Inglis, O.B.E., M.A., LL.D., F.R.S., President of the Institution of Civil Engineers, who was supported by Mr. W. A. Stanier, President of the Institution of Mechanical Engineers.

LOCOMOTIVE BALANCING.

A paper dealing, in the main, with the same subject was presented by, and before, each institution, viz., one entitled "Hammer-blow in Locomotives: Can it not be Abolished Altogether?" by Sir Harold N. Colam, B.A., M.Inst.C.E., and Major John D. Watson, R.E., B.Sc. (Eng.), A.M.Inst.C.E., and one entitled "Balancing of Locomotive Reciprocating Parts," by Mr. E. S. Cox, A.M.I.Mech.E.

Sir Harold Colam and Major J. D. Watson restricted their survey to the case of locomotives with outside cylinders and explained that their object was to submit evidence in support of the contention that, in modern locomotives, overbalance was unnecessary. They thought it advisable to discount in advance the effect of certain remarks made by the Committee sent to India in 1938 to investigate defects in Pacific-type locomotives. The Committee visited the Madras and Southern Mahratta Railway and recorded their opinion of two "RO" engines in the words: "Reciprocating weights had been unbalanced and there was, as a result, fore-and-aft vibration," and "owing to the absence of balance of reciprocating parts it was very rough and there was much vibration with short-period nosing and shuttling." It was exceedingly difficult, the authors contended, to isolate the effect of one feature of an engine, and this was doubly or trebly true when experience was limited to one short run; against these adverse criticisms was the fact that 75 "RO" engines were in daily use on that railway. No trouble had been experienced that could be connected with lack of overbalance, and the Chief Mechanical Engineer was satisfied that no difference could be detected between these engines and others, normally balanced.

The authors were of opinion that the subject of locomotive balancing was increasing in importance. There had been a widespread move to increase railway speeds in most countries, and already there were indications that this would introduce new troubles. In America, it had been discovered that, with certain locomotives at very high speeds, the main driving wheel lifted clear of the rail at one point in its revolution. Apart from any risk of derailment, this must increase rail and bridge stresses to values dangerously near to, or even beyond, the safe limits. Their view was therefore, that a *prima facie* case had been established for abolishing overbalance.

Mr. Cox said that, since the British Bridge Stress Committee made their report in 1938, the speed capacity of locomotives had increased. After showing how the recommendations of the Committee had been met in modern British locomotive design, he discussed the effects of higher rotational speeds and gave the results of tests of the lifting of coupled wheels off the track at high speeds and with various proportions of the reciprocating weights balanced. As the necessity might arise to reduce hammer-blow values still further in order to meet the civil engineers' requirements, Mr. Cox continued, the possibility of reducing or eliminating the amount of reciprocating balance became important. He, therefore, discussed the effect of this factor on the locomotive, from the theoretical standpoint, gave expressions for evaluating the amplitude of the resulting horizontal and lateral oscillations, and summarised the available practical evidence.

The conclusions reached, regarding the conditions under which it was still necessary for locomotive reciprocating parts to be balanced, were as follows:—(*a*) Longitudinal and nosing oscillations depend on the weight and length of the engine, the weight of reciprocating parts unbalanced, and the characteristics of the drawbar springs, but are independent of speed; (*b*) theory suggests that three-cylinder and four-cylinder engines which are already in a state of balance with regard to longitudinal forces do not require any portion of their reciprocating parts to be individually balanced to deal with the nosing couple, because of the small magnitude of the displacement—three-cylinder engines with zero reciprocating balance are already running in this country; (*c*) in two-cylinder engines, theory (supported by a certain amount of practical evidence) indicates that some reciprocating balance is still required if undue longitudinal oscillations are to be avoided, and, while the percentage required will vary with the engine characteristics, not less than 40 per cent. balance appears to be necessary on the heavier type of British two-cylinder engine, weighing from 65 tons to 75 tons; (*d*) for the highest speeds, therefore, multi-cylinder engines are the most desirable, the four-cylinder being preferable to the three-cylinder type from the point of view of hammer-blow if it is thought necessary to balance a percentage of the reciprocating parts, though, if this balance is eliminated, there appears to be little to choose between the two types; (*e*) the final criterion of the percentage of balancing necessary is the magnitude of the permissible oscillations, having regard to riding comfort, wear and tear, maintenance costs, and safety; (*f*) practical experience tends to support the theoretical conclusions, but it is very scanty and needs to be supplemented by scientific investigations to establish the precise effects of the unbalanced parts on the locomotive and to define the limiting value of the disturbances that can be allowed.

In opening the discussion, Professor Inglis said he had held for some 40 years the view that there was no real scientific justification for balancing the reciprocating parts of a locomotive. In his work in connection with the British Bridge Stress Committee, these early convictions had been confirmed and it was pleasing to find from the papers just presented that the need for putting up with hammer-blow as a result of overbalancing was challenged.

Mr. Stanier followed, and, in referring to the hammer-blow records of the first paper, said that the authors seemed to doubt some of the conclusions come to by the committee which visited the Madras and Southern Mahratta Railway in 1938. He had ridden on some of the locomotives concerned and doubted whether the railways in India knew what proportion of balance weights they were really putting in, for one thing, it could not be assumed that the wheels were homogeneous. The G.W.R. and other British railways might be wrong in the proportion of the balance weights they added, but what they intended to do, they did. The mass of an engine had an enormous influence on balancing and the effects were difficult to assess on the footplate. So far, the only practicable means over here for measuring the effect of the reciprocating balance was the use of a dynamometer car with a

weak spring which gave some indication of any fore-and-aft movement, but the results were affected by many factors. Mr. Cox had given particulars of a 4-6-0 engine without reciprocating balance, which had no detrimental effect on the wear of the axle boxes and parts. Were hammer-blow to be eliminated from locomotives, how much extra load would the civil engineer allow on the axles?

The next speaker, Mr. George Ellson, exhibited some slides showing curves of deflection tests and Hallade records of trials with a Merchant Navy locomotive at speeds up to 50 m.p.h., designed without balance weights, a H.15 type, with and without balance weights at the same speed, and a recently-designed electric locomotive at speeds of from 60 m.p.h. to 80 m.p.h. In considering the general problem, he held that a wide view should be taken embracing both the track, in its widest sense, and the locomotive. It should be borne in mind that the present track, though meeting conditions prior to the high speeds introduced in the last few years before the war, any normal running with such speeds now would involve considerably higher expenditure on it, since every dynamic influence exerted by the locomotive detrimental to the track increased as the square of the speed.

The contribution of Mr. F. C. Johansen, M.Sc. (Eng.), took the form of some comments on a slow-motion film of the wheel-slipping experiments referred to in Mr. Cox's paper and confirming the observations made in the United States and mentioned in the paper by Sir Harold Colam and Major Watson. The tests made by the L.M.S. Research Department were largely qualitative and were primarily intended to discover whether the Class 5 mixed-traffic two-cylinder engines, suspected of damaging rails, could be made to bounce off the rails by slipping them at high rotational speeds on a greased surface. Secondly, to observe any results attendant on the reduction, below the two-thirds proportion, of the reciprocating mass balanced. The camera was focussed upon the main driver, *i.e.*, the intermediate coupled wheel, as its bouncing movement was more pronounced than that of the wheels each side of it. Once the wheel had re-bounded the effect tended to increase. It was observed that, although there was some evidence that reduced track stiffness increased the extent to which the rails were damaged, wide differences in the condition and stiffness of the track had no apparent effect upon the speed of rotation at which the driving wheel began bouncing. The rotational speed at which the wheel just started to bounce must be a function of the inertias of the wheel and engine and of the elastic-spring characteristics of the track and bearing spring. Before separation of wheel and rail the system was analogous to a mass carried by springs between two relatively rigid supports, viz., the ground and the massive body of the engine. The behaviour of the wheel under vibration from the out-of-balance cycle was thus affected by track stiffness in combination with other factors. It was likely, however, that the weaker spring (the bearing spring), preponderated over track stiffness on British railways.

The rail under the right hand wheels was more severely damaged than that on the left hand side. This effect was observed on both ballasted and unballasted track in both directions of travel. Some lateral oscillation was visible in one of the tests shown in the film. None of the engine frames suffered appreciable vertical oscillation, but lateral oscillation of the trailing end of the body and of the trailing coupled wheels was marked in that test, in which the engine had only 30 per cent. of the reciprocating weights balanced. While the vertical oscillation was most pronounced in the centre wheels the severest lateral oscillation was in the trailing wheels. It might be that the axis of lateral oscillation was not the centre of gravity of the engine, but the pivot of the leading bogie truck. Flange burns on the inner sides of both rails were evidence that the amplitude of lateral oscillation of the trailing coupled wheels was as much as the available clearance of 0·625 in. with each of the three engines.

Mr. J. C. L. Train held the view that the interests of the bridge and the permanent way engineer were identical as regards hammer-blow, and referred to tests on side pressure carried out on the P.L.M. Railway, in which the side pressure was found to be 6 tons on the straight and 13·5 tons on a 35-chain curve, these figures agreeing fairly with the calculated side pressures for these conditions. He thought the solution of the hammer-blow problem was to use multi-cylinder engines.

Mr. O. V. S. Bulleid observed that so far no ill effects from the absence of reciprocating balance were observable when precautions were taken in other directions, moreover, the absence of this balance was important as saving dead weight. The effects of lack of balance could be reduced by using a shorter piston stroke so minimising the inertia effect. The rubber springs referred to by Professor Inglis tended to damp out oscillations between the engine, the tender and the train and no ill consequences had been observed from this departure from conventional practice.

Mr. W. K. Wallace pointed out that the elimination of hammer-blow for new classes of engine might lead to re-timing some specific trains which, in turn, might be followed by the speeding up of trains drawn by older classes of engine having hammer-blow. This might result in serious damage to the permanent way. The locomotive engineer would like to omit reciprocating counterbalance, but this might result in lateral motion which would abuse the road; and the roads of this country were not so stiff against lateral loads as where flat-bottomed rails were used. There was likely to be a demand after the war for heavy ultra-speed trains. The engines used for present limited trains of this class had multi-cylinder engines to give the high tractive effort required and were not so important from the hammer-blow point of view, but heavier trains must be visualised. Meanwhile, the two-cylinder mixed-traffic engine with a modern valve gear and high rotational speed called for watchfulness by the permanent way engineer.

Mr. Conrad Gribble, referring to the work of the Bridge Stress Committee, about 1928, said that, at the time the position was a very safe one. There was, for instance, a class of engine on the old L.N.W. Railway which had four cylinders driving the same axle and no outer balance. This engine had no hammer-blow. The three-cylinder engines had only negligible hammer-blow.

The comments of Sir Alan Mount were mainly on the records made in the tests on the Madras and Southern Mahratta Railway. He concluded by remarking that there had been in this country high speed derailments in which difficulty had been found in accounting for the cause, though the relief of weight due to the upward force of the hammer-blow might have been a contributing factor.

Mr. E. C. Poultney, O.B.E., dealt chiefly with the changes in balancing technique which had taken place when the cylinders were placed outside the engine instead of inside, which practice had increased the weights required to balance the reciprocating parts. He exhibited some slides which showed that the disturbance caused by an outside-cylinder engine was much greater than that from the older inside-cylinder engine.

Mr. J. J. C. Paterson was of opinion that in considering the arguments of both papers the question of speed must not be overlooked. The tests described were largely based on speeds of 60 m.p.h. to 65 m.p.h. but conditions were very different at speeds of round about 120 m.p.h. Further, it was not perhaps realised that the permissible movement of an engine in the transverse plane was exceedingly small. If there were an angular displacement of, say, 1·5 deg. on either side of the mid-position, the result was an oscillation of very large amplitude for a locomotive. The problem of balancing could hardly be viewed as one of technical interest only but was also a matter of considerable financial importance. The question was complicated by the necessity of assessing the different claims of the multi-cylinder engine, the compromise of the balancing of the two-cylinder engine, and the policy of increasing the static load as against retaining existing bridges and permanent way.

Major Watson, who read the first paper in the absence of Sir Harold Colam, then replied briefly and was followed by Mr. Cox, both gentlemen, however, reserving a fuller discussion for a written reply.

RESEARCH IN COAL UTILISATION.*

THE research programme of the British Coal Utilisation Research Association for the year 1940 was devoted to three main investigations. The first was the development of a portable gas producer for use on road vehicles. The second was to find a suitable gas-producer fuel which could be produced in large quantities from coals available throughout the country. The third was to endeavour to improve the utility of large boilers by reducing the tendency to stoppages in boiler and superheater tubes by deposits carried over from the fuel bed. In all these investigations, the foundations of success were laid in 1940, and during the present year, very satisfactory results have been obtained.

The importance of producer gas as an alternative to petrol for road vehicles has been somewhat overshadowed by disappointments during the period of development which followed the outbreak of war. We are well aware of the extreme technical difficulty of making producer gas in small portable equipment, with a flexibility sufficient to meet the rapidly changing demands of road operation. This difficulty is greatly enhanced when one attempts to use solid fuels derived from coal in place of the charcoal fuel which is almost exclusively employed on the Continent. It was reported recently in the Press that the Germans are saving 11,000,000 gallons of petrol a month by the use of producer gas; but we know that, in spite of their abundant supplies of charcoal, these results are being obtained with considerable sacrifice of operating efficiency. We set ourselves the task of making it possible to replace petrol with fuels derived from coal, without making excessive demands upon the skill and care of the driver. Only those who have been directly engaged in this problem can appreciate its great technical difficulty. This entitles us to regard with satisfaction the fact that, in the short space of 18 months, we were able to place on the road a number of vehicles operating on producer gas which have been giving service which compares not unfavourably with that obtained from petrol. The vehicles range from small private cars to heavy lorries, some with trailers and some with the producer mounted on the vehicle itself. On the subject of producer gas fuels, it is necessary to be reticent; but it is now possible to produce, in large quantities, fuels suitable for gas producers making use of coals available in three-quarters of the coal-producing districts of England, Scotland and Wales.

The third group of investigations upon which we were engaged in 1940 refers to large steam generators. It is well known that the principal cause of outages of large boilers in all industrial countries is the fouling of external heating surfaces by adhesive deposits. These troubles have increased rather than diminished as the size and ratings of boilers have advanced. In 1938, the Association was entrusted by the makers of boilers and stokers, with the co-operation of the electrical industry, with the task of making a fundamental investigation of the causes of these deposits, to ascertain whether they could be avoided by modifications either in operation or design. A preliminary investigation of published work on boiler deposits showed that no less than 160 different causes had been proposed at one time or another to explain their origin. Some of these suggestions were diametrically opposed to one another, so that it was obvious that the fundamentals of the problem were then obscure. It has required three years of investigation, and the use of research methods hitherto untried in combustion engineering, to trace the origin of these troubles. We have gone farther than this, and have shown that it is possible, by operating adjustments, to reduce deposits so considerably that the life of boilers can be increased three- or four-fold. Tests made over a period of months in one of the principal Midland power stations confirmed our findings in this respect. This work is being actively pursued with the help of valuable facilities made available to us by Messrs. Babcock and Wilcox, Limited, on their experimental high-pressure boiler at Renfrew.

Apart from these main lines of investigation, we have undertaken a number of researches on behalf of industrial coal users and Government Departments. There is one, in particular, which illustrates the advantageous position in which an industrial research association is placed in applying research results to commercial conditions. We were called upon, in the autumn of 1940, to devise a means of heating public air-raid shelters with coal, which could be guaranteed to be as free as possible from the danger of carbon-monoxide poisoning. The short time available before winter made it impossible to investigate the problem fundamentally, but we were able, in a few weeks, to supply the Ministry of Home Security with a

* Extract from the presidential address of Sir Evan Williams to the British Coal Utilisation Research Association, delivered at the annual general meeting held in London on Wednesday, December 10, 1941. Abridged.

stove, and to produce conclusive test results showing that it could be adopted with safety. We were then called upon to make manufacturing arrangements for 50,000 stoves within a few weeks. Through our contacts with the manufacturers, we were able to help the Ministry of Supply in getting production under way and, since then, nearly 70,000 Cura stoves have been purchased for public air-raid shelters, in addition to many thousands of others for use in Government factories and private shelters. The Association received special thanks from the Minister of Home Security for this work, the whole cost of which was met out of public funds.

THE MANUFACTURE OF ARTICLES FROM POWDERED METALS.*

By W. D. JONES, M.Eng., Ph.D.

MOST engineers and metallurgists, and probably a good many technicians concerned with plastics, appear to find it difficult to believe that articles and masses having good physical properties can be made by moulding metal powders, and that the art shows every sign of rivalling the plastics industry in magnitude during the next decade. The possibilities of the technique and the phenomena involved are more easily appreciated if two things are borne in mind; first, that, very broadly, the technique follows that of the plastics industry; and secondly, that the principal phenomenon involved in moulding metal powders is that of simple welding.

It is interesting to note that all the well-known circumstances attendant on success or failure in the welding of solid metals are equally present in powder metallurgy. For example, soft low-carbon steels and soft metals, such as copper and gold, are easily welded in mass or in powder form, while hard or brittle metals, such as high-carbon steels, cast irons, antimony, bismuth, etc., are not so amenable. Moreover, it is well known that dirty surfaces, oxide films or various tarnish films are obstacles to welding in mass and they are equally so with powders. The methods of overcoming such obstacles in massive welding (or soldering or brazing) involve the use of fluxes or of reducing gaseous atmospheres such as hydrogen or ammonia. Such methods can be, and are, used in powder metallurgy.

In connection with massive solid welding there is, however, a popular fallacy very widespread among engineers and metallurgists: this is the belief that welding is necessarily a phenomenon which only takes place at high temperatures. Such a belief is quite wrong. It is true that in most cases it is easier or more convenient to work at elevated temperatures, but this is only because metals are more plastic at such temperatures and are more amenable to shaping, and also because at high temperatures it is easier to arrange for fluxes and atmospheres to be sufficiently reactive to reduce or dislodge oxide or other films which would obstruct the welding operation. In point of fact, welding phenomena can take place at any temperature, and there is considerable evidence to indicate that the primary cohesive surface forces which produce welding phenomena are stronger at room temperatures than at elevated temperatures. This point of view may be unfamiliar and to talk about "cold welding" may sound very strange, but in reality cold welding is a very frequent and ordinary phenomenon. Most people, unfortunately, have come into contact with the seizure of bearings, or the seizure of a nut and bolt when screwed up too hard; those are examples of cold welding. The intermittent and jerky nature of frictional forces are indicative of intermittent and momentary seizures or cold welding. The cohesion associated with the wringing together of block gauges is another example, and there are, in fact, numerous instances of it in everyday engineering practice. The phenomenon is most easily and quickly demonstrated if two pieces of tin are given flat freshly-cut surfaces, as, for example, by a guillotine. It will be found that the two surfaces will adhere quite strongly if lightly pressed together.

A simple experiment of this type is very suitable for revealing some of the principles of cold welding. For example, it will be found that adhesion is more readily obtained with the softer metals, such as tin and lead, not so readily with copper and gold, and not at all (using hand pressure) with steels and nickel and tungsten. This is merely because the harder metals will not deform readily under the forces involved. Moreover, it can be shown that exposure to the air for any length of time, so that oxide or tarnish films are formed, prevents cold welding; and even the momentary touching of a freshly cut surface with the apparently clean finger destroys the phenomenon.

* Paper read before the Manchester Association of Engineers on Saturday, December 13, 1941. Abridged.

Special attention has been drawn to this phenomenon of cold welding because precisely the same phenomenon occurs when metal powders are compressed. Simple applied cold pressure in a die on a freshly prepared copper or gold powder will produce compacts of quite surprising strengths entirely by virtue of the cold welding that is taking place between each particle.

There are, of course, other phenomena involved and some of the strength of powder compacts is due to the simple mechanical interlocking of the individual deformed particles. One must also consider the extensive surface area of a metal powder and therefore the large degree to which a metal powder can become damaged in a very short time by oxidation or the formation of deleterious surface films. Perhaps it might be interesting to point out that if a cubic inch of solid metal is taken and divided up into a powder having spherical particles of equal size, then if it were a 400-mesh powder the total surface area of the particles would be about 1 sq. ft.; if the particles were 10 microns in diameter (which is nothing very unusual) the area would be about 90 sq. ft. It is frequently the case that metal-powder specifications call for a 300-mesh or 400-mesh powder having an oxide or impurity content of "less than 0·5 per cent." or of "less than 0·1 per cent." Such specifications are quite difficult to meet, much more so than in the case of cast metals.

The Manufacture of Metal Powders.—It will perhaps be of interest to say something on the subject of the manufacture of metal powders. There are, in fact, a wide variety of methods employed, and in many cases some methods are specific to certain metals or alloys. Copper powder, which is employed in this country for the manufacture of porous bearings in considerable tonnage, is made by several different methods, of which the most important involve electrolytic and reduction processes. In the first the powder is thrown down on the cathode in the electrolytic refining process. This is by no means a simple process to operate commercially and considerable knowledge and experience is necessary to produce powders meeting consumers' specifications with respect to particle size, oxygen content, and other properties. In the reduction process a commercially-pure copper oxide, in powder form, is reduced to metal by heating in a reducing gas such as hydrogen, or more usually, purified coal gas. This is a process which is very simple to achieve in the laboratory but which is difficult to operate successfully under commercial conditions.

More recently a type of spraying or atomising process has come to the forefront and commercial experience with it is being acquired. As might be imagined, it is no simple matter to spray molten copper; nevertheless processes along these lines are in operation in this country for copper and have been employed for many years in connection with aluminium, lead, solder, and tin powders. The tin powders, used in conjunction with copper for the manufacture of porous bearings, are generally made in this way.

Iron powders are also manufactured by the methods employed for copper, but the powder which hitherto has been the most popular in powder metallurgy, namely Swedish sponge-iron powder, is made by heating together a mixture of powdered iron oxide and powdered coal packed in crucibles in a brick kiln. The reduction method is largely used for a number of other metals, particularly tungsten, titanium, molybdenum, and cobalt. Mechanical methods of comminution such as ball milling are also in extensive use in the manufacture of powders generally, but have not hitherto proved popular in connection with powders specifically employed for powder metallurgy.

Powder Metallurgy Processes.—The manufacture of bearings in porous bronze is well established in this country and they are extensively employed in all fields of engineering, particularly in automobiles, aeroplanes, electric clocks, sewing machines, refrigerators, and vacuum cleaners.* The porosity of these bearings normally varies between 25 per cent. and 40 per cent. by volume and is susceptible of very exact control in manufacture. In many cases the amount of oil which they contain is sufficient for their natural life although, of course, they can still be fed with oil in the normal way, in which case the pores act as a capillary filter for solid foreign particles. These bearings are particularly economical in oil and one important advantage which is claimed for them is that a continuous lubricating film always exists over the whole bearing surface even before rotation of the shaft commences.

The successful manufacture of these bearings is not a simple matter. The process commences with copper and tin powders made to very carefully drawn-up specifications. Generally the particle size is of the order of 200 to 300 mesh and they are mixed together in a 90/10 proportion. Some manufacturers add a small percentage of powdered graphite and others a small percentage of a lubricant to facilitate the pressing operation. Various types of presses are employed.

* See ENGINEERING, vol. 152, page 128 (1941).

The development of this industry took place using a slow-speed hydraulic press and this type of press is still employed for the largest sizes of bearings. The present normal manufacturing output, however, is obtained by means of high-speed mechanically-operated presses of the type which are extensively employed in the pharmaceutical industry for manufacturing tablets and pills. Such presses are of the eccentric, cam-operated or rotary type. They provide for rapid operation, of up to 500 pieces per minute, the automatic feed of the correct weight of powder, pressing, and automatic ejection. The manufacturers of these types of presses have been very ingenious and successful in devising means of balancing loads and distributing pressures in dies of various complicated shapes. This is a much more difficult proposition with metal powders than is the case with pressing plastics, because metal powders possess little ability to flow under pressure in a die, with the consequence that considerable frictional forces, are easily set up. In a pressing of any considerable depth, therefore, it is generally desirable to press from both ends simultaneously and such a procedure is generally followed, combined with a movable core rod in the case of bushing dies. When compared with eccentric presses, cam-operated presses have greater flexibility in the stroke and timing of both upper and lower punches. Rotary presses give a slow squeeze rather than the rapid punch associated with the cam press, and allow more time for the escape of air. They are employed for producing large quantities of plain cylindrical sleeve bearings which only require equal compression from upper and lower punches. The pressures involved are generally of the order of 20 tons per square inch and the maximum thrust obtainable on marketed presses of this type appears to be 90 tons, which sets a limit of some 5 sq. in. of projected pressing area to the pieces that can be made. Pressings larger than this have still to be made by hydraulic presses. A typical press of the cam type produces bushings up to 2 in. diameter with a wall thickness of $\frac{1}{16}$ in. at the rate of 15 to 45 per minute, and gives a maximum load on the piece of 30 tons.

The compacts, on ejection from the press, are quite strong enough to handle and must then be heat-treated or sintered. The furnaces employed are developments of the usual type of continuous brazing or bright-annealing furnace. Different manufacturers employ varying designs and sizes, but they all consist essentially of a long narrow straight-line muffle furnace in which the compacts are pulled or pushed, or conveyed on a travelling mesh belt, or a roller hearth, through a heated zone and then through a long cooling zone. A protective atmosphere is maintained in the furnace. A typical furnace would have a heating chamber some 4 ft. long taking trays or a belt 12 in. wide and having an overall length of some 35 ft. It would operate at a temperature of 750 deg. to 850 deg. C. and require about 36 kW. The parts would be in the hot zone some 10 minutes. Many electrically-heated furnaces are fitted with several heating zones, independently wired, so that a controlled temperature-time cycle can be given to the pressings. It is also frequently desirable to fit such furnaces with most accurate temperature-control apparatus. While it is possible to use atmospheres such as hydrogen or "cracked" ammonia, it is nevertheless generally considered necessary to employ a cheaper atmosphere, namely "combusted" coal gas. The General Electric Company, of the United States, and the Gas Light and Coke Company, in this country, manufacture suitable plants in which city gas and air are mixed in the correct proportion and "combusted" over a catalyst, the water being subsequently condensed. In some cases the gas may be dried completely and purified before passing on to the sintering furnace. In this way it is possible to obtain and use a cheap suitable gas which can be varied from strongly reducing to more or less neutral in character. A furnace of the size mentioned would consume some 180 cub. ft. to 200 cub. ft. of raw gas per hour.

During the sintering or fritting operation, the tin melts and gradually alloys by diffusion with the copper. The best results are not necessarily obtained by complete diffusion, and commercial specimen bearings which display several structures of the copper-tin system have been examined under the microscope. In melting and diffusing, the tin leaves voids which form the pores.

One of the most important advantages possessed by the powder metallurgy technique is that articles can be made exactly to size and shape without machining. During the sintering stage dimensional changes occur which may be either a growth or a shrinkage, generally the former, and one of the difficulties in manufacture is the close control of these changes. In practice this implies a very careful control over the quality of the powder, the composition of the mixture used, the pressing operations, and the exact time and temperature cycle in sintering.

After sintering, the bearings are impregnated with lubricating oil, either by soaking for 10 minutes or

15 minutes at 110 deg. C., or at lower temperatures in a vacuum chamber. Finally the bearings are sized to the necessary tolerances in a mechanically-operated sizing press which may be a suitably-modified type of the familiar punch press or merely the original powder press. On much the same lines, porous bronze compacts are being manufactured and sold as filters for various solutions. Bronzes, copper-nickel alloys and pure nickel are used for this purpose. The porosity varies over a wide range and may reach 80 per cent. by volume. They are used not only in the chemical industry but in domestic refrigerators and domestic oil heaters. One filter, some 5 in. long and 2 in. in diameter, has been developed as the fuel filter in a Diesel engine. Also much on the same lines, bearings and valve guides are being manufactured from iron powder and mixtures of iron powder and copper.

One of the most remarkable developments in powder metallurgy recently announced in the technical Press* is the copper-nickel bonded Babbitt bearing of the General Motors Corporation. This has been developed as a result of an attempt to find something having a higher strength than the tin-base bearing metal and a higher corrosion resistance than the normal lead-base material. The research and development involved n this process has been very considerable although it is possible here to give only a brief outline of the process as it has now been put into commercial operation. A cold-rolled steel strip from 1 in. to 20 in. wide is passed between roller levellers and then into an alkaline cleaning bath and finally washed and dried. A mixture of 45 per cent. nickel powder, of 80 mesh to 100 mesh, and 55 per cent. copper powder, of 100 mesh to 200 mesh, is then spread upon the steel strip to a depth of 0·02 in. The strip is passed over brushes to remove dirt and powder from the underside and then passed into a sintering furnace. This contains four sintering zones and is fitted with a roller hearth 18 ft. long and a cooling hearth 21 ft. long. Here the powders are sintered or fritted for a short period at 1,100 deg. C. During this fritting stage the copper powder melts and brazes the nickel powders to the steel strip. The time of fritting is short so that the degree of alloying of the copper with the nickel or the steel is comparatively small. A reducing atmosphere is of course maintained in the furnace. After cooling, the strip passes through chromium-plated sizing rolls which "squeegee" the copper-nickel sponge under a pressure of some 5 tons per square inch. The strip is then reeled. Before the next stage, successive reels of strip and sponge are welded together and pass through a molten lead-base alloy bath containing some 3 per cent. of tin and 3 per cent. of antimony. Here the pores of the sponge become impregnated with the bearing metal, but to make sure of complete impregnation the strip is next passed into a heated chamber in which a vacuum of 6 mm. to 7 mm. of mercury is maintained. Finally, the strip passes under water jets where the bearing alloy is chilled. Subsequently the strip is milled on both sides and a proportion of bearing metal removed and the amount of strong nickel-copper sponge exposed adjusted according to the type of service the bearing is expected to withstand. The material is then stamped and blanked to form half shells, each of which is chamfered and broached.

The familiar hard-metal carbide materials for cutting tools, known as Widia, Ardoloy, Cutanit, etc., are manufactured from powdered products and the modern contact material is another fine example of the application of powder metallurgy. Successful electrical contact materials are required to possess a formidable range of qualities. They should embody, in one alloy, high electrical and thermal conductivity, high melting point, high hardness and wear resistance, low contact resistance, low vapour pressure, resistance to the formation of tarnish films and resistance to welding and the formation of pits and beads caused by arcing or the transfer of metal from one contact to the other. There is no known cast metal or alloy which has any pretension of being able to meet all these requirements at one and the same time. It is possible and perfectly practicable by powder metallurgy, however, to combine the high hardness, resistance to welding and pitting, and high melting point of tungsten or molybdenum or tungsten carbide, with the much superior thermal and electrical conductivity and contact conductivity of copper or silver, and to produce a material having the individual qualities of both. It is important to note that the two substances, although combined in an extremely fine state of division, are nevertheless not alloyed and therefore both substances preserve their qualities uninfluenced by the other. This is a state of affairs which could only be attained by means of the powder metallurgy technique. An extensive range of such contact materials is now manufactured, including, among other compositions, tungsten-copper-tungsten-silver, molybdenum-silver, tungsten carbide-silver, silver-nickel, and silver-graphite. The processes by which they are manufactured follow the standard technique of powder metallurgy and are not in any way remarkable.

The Alnico magnet is also a very fine example of the modern powder metallurgy technique. The composition is somewhat variable according to the grade and manufacture, but, in general, consists of from 9 per cent. to 13 per cent. aluminium; 17 per cent. to 24 per cent. nickel; 5 per cent. to 12 per cent. cobalt; sometimes copper, and the remainder iron. This composition is a most undesirable material to melt and cast and the situation is made much worse by the fact that these magnets are frequently required in very small sizes (weighing as little as 0·15 gramme) and often in very complicated shapes. Moreover, the alloy has a high melting point which is in the neighbourhood of 1,500 deg. C., and is very sticky and sluggish when molten. It is also very difficult to prevent the aluminium from being lost by oxidation. The cast alloy is mechanically weak and easily broken in shaping, and, in addition, is far too hard to be shaped other than by grinding. It is not difficult to understand, therefore, that once this magnet material became popular, attempts were soon made to manufacture it by the methods of powder metallurgy. These attempts have been successful, but not without extensive research work. Actually, the method now employed follows very closely that used for the manufacture of hard-metal cutting tools, with modifications introduced principally on account of the presence of aluminium in the alloy. It is almost impossible to reduce aluminium oxide by sintering without the use of metallic hydrides and this caused one of the principal initial difficulties. This obstacle, however, was overcome by adding the aluminium in the form of a 50/50 iron-aluminium alloy. The mixed powders are pressed in the normal type of tableting press described earlier, and are then pre-sintered in hydrogen at 600 deg. C. This treatment imparts sufficient strength to them to enable them to be machined more or less accurately to size, taking into account the subsequent shrinkage in sintering. Lastly, they are sintered again at approximately 1,400 deg. C. in an atmosphere of very pure, very dry hydrogen. The temperature is above the melting point of the Fe/Al constituent and therefore diffusion of the elements is fairly rapid and homogeneity is soon reached.

Further examples of circumstances in which it is more convenient or better to use the powder metallurgy technique than casting are afforded by the refractory metals, such as tungsten, molybdenum, tantalum, platinum, etc. All these materials can be cast, but it is an expensive and difficult process, in view of the high melting points, and, in many cases, the cast product is not so satisfactory as that made from powders. It is particularly interesting to note that platinum has been worked up by powder metallurgy from the very earliest days and the details of the process were described by Wollaston in 1829.

Many iron parts are now made by powder metallurgy and one which constitutes a remarkable achievement is an automobile oil-pump gear wheel. This is a small gear used to circulate the oil in cars produced by the General Motors Corporation. The gear teeth must be true involute curves and accurately formed to avoid binding or noisy operation. In the past, the component has been machined from a cast blank at considerable expense. The powder metallurgy product is in every way superior and cheaper. Numerous advantages have been mentioned in its favour, but it will suffice to state that machining costs and the waste of raw material are avoided, and that the gear has a more accurate contour and better surface, and is, therefore, more silent in operation. Iron parts of this type are manufactured much on the lines used for the porous bronze bearings. Similar presses can be used, but the pressures are higher, namely, from 30 tons to 40 tons per square inch. The sintering furnaces are similar and the sintering temperature is in the region of 1,100 deg. C. Furnaces fitted with roller hearths or wire-mesh conveyor belts are employed. The sintering time is from 20 minutes to 40 minutes in an atmosphere of dried, partially "combusted" hydrocarbon gas. There is generally a slight shrinkage during sintering, amounting to from 0·5 per cent. to 3 per cent. In most cases the pieces are sized after sintering, generally when cold, but in some cases at temperatures of from 400 deg. to 500 deg. C. Iron parts made in this manner have been produced experimentally with tensile strengths exceeding 50 tons per square inch, but with the qualities of iron powder at present commercially available, and bearing in mind that wear on the dies increases with the pressure employed, it is not customary to exceed a tensile strength of from 9 tons to 15 tons. These parts can, therefore, be regarded as having properties very similar to those of ordinary cast iron. As commercial experience is gained it will become possible to make use of the results of laboratory investigations in which higher pressures and alloy-steel powders have been employed.

In hot-pressing methods of moulding, pressure is imparted to the powder while it is cold and the cold-compressed compact is heated up and then pressed again while it is hot. There are a variety of methods by which the process can be worked out, and, in some cases, hot forging or hot extrusion are made use of. The process is not a difficult one, but, so far, has received little or no industrial attention. The writer has examined a wide variety of alloys prepared from powders by this technique and finds that it not only combines all the advantages usually associated with powder metallurgy, but, in addition, is capable of giving compacts having excellent mechanical properties, and, in some cases, properties superior to those of the cast article. These results have been published in detail and it will be sufficient to state here that with an ordinary cast iron, tensile strengths of 36 tons per square inch have been obtained, and with bronzes, tensile strengths in excess of 23 tons per square inch combined with an elongation of upwards of 75 per cent. Similar results are obtainable with brasses and various other copper-base and complex alloys.

Recently an account has been published* describing the application of hot pressings to the manufacture of steel parts from turnings. The process has been worked out in a very simple manner and appears to be highly successful. Starting with steel turnings valued at little over ½ cent per pound, a part is produced which has approximately three times the strength of cast iron. The part concerned, which is produced in six operations without machining, is a lock sleeve used to hold the roller bearing in the differential carrier of the Chevrolet car. It is about 3 in. in diameter, ⅛ in. thick, and has a thickness, in section, of ⅜ in. One face, which is at an angle of 20 deg., is smooth, and the other has concentric recesses near the inner and outer edges. It weighs 8 oz., and was previously machined from grey cast iron.

The powder metallurgy method is as follows:—Steel chips and turnings are fed into a swing-hammer crusher which reduces them to a very coarse powder. They are then compacted in a hydraulic press under a pressure of some 30 tons per square inch. The parts are then treated in a pusher type sintering furnace fed with "combusted" gas. The furnace is capable of dealing with six parallel tracks of parts at a rate of 500 pieces per hour giving each part approximately 15 minutes treatment at a maximum temperature of about 1,050 deg. C. As the pieces emerge from the sintering furnace they are quickly transferred by hand to the hot press. The dies used are of the hinged type and water cooled and have a series of eight jaws applying pressure uniformly around the outer edge while upper and lower dies compress the surface. Pieces are dealt with at the rate of 12 per minute in this press, and are automatically removed from the dies and slide down a chute into a water-quenching bath. When cool the parts go to a trimming press and are then finally sized.

Limitation of Powder Metallurgy.—From a purely technical point of view, it must be remembered that metal powders present very considerable frictional resistance in a pressing die and will not flow to anything like the same extent as do most plastic materials. This is a fundamental matter and must always be borne in mind. It prevents, for example, the manufacture of pressings having extremely thin sections in the direction of pressing or of pressings having re-entrant angles. It is not possible to make the wide variety of forms that can be produced by die casting. There is also, at the present time, a very definite size limitation if the parts are to be produced in large numbers from comparatively inexpensive equipment. There is, however, no real upper limit to size, provided sufficiently large presses are available. There are now, moreover, composition limitations and limitations to the type of mechanical qualities procurable in sintered parts. This is, however, largely due to inexperience and to the slowness with which development work is transferred to the workshop. In consequence, the metal-powder manufacturer has not been encouraged to put on the market wide varieties of alloy-metal powders. Finally, powder metallurgy has one limitation in common with processes of the die-casting type, and this is that a sufficiently large number of any one part must be required to offset the costs of the die and plant. This minimum number is, of course, related to the design of the particular piece and to various other circumstances. Within this range of limitations there are, however, a very large number of parts that can be made profitably by powder metallurgy and it is very much in the national interest that some of them, at all events, should be produced in this manner.

Coal Production in the United States.—The production of bituminous coal in the United States during the week ended November 22 averaged 1,564,000 tons daily, compared with 1,968,000 tons in the previous week and 1,827,000 tons in the corresponding week of 1940.

* See *Metal Progress*, vol 38 (2), page 173 (1940).

* See *Steel*, vol. 108, page 75 (1941).

NOTES FROM SOUTH AMERICA.

ALTHOUGH the Lease-Lend arrangements with the United States must continue to impose severe restrictions upon the export to South America of the products of British heavy industries, the position is relieved to some extent from time to time, according to Britain's seasonal purchases of South American products. Thus, export licences are now being issued more freely for Chile, and it is understood that the question of shipments to Brazil, Colombia and Peru has been under revision by the Board of Trade. The fact is that, due to the shortage of shipping, the concentration of British industries upon war work, and the operation of the priority delivery system in the United States, there is now a definite shortage in Latin America of essential imported goods, notably fuel and materials required for public utility companies, national manufacturing industries, etc. Broadly speaking, it appears that South American importers are now willing to buy, and are able to obtain the necessary exchange cover for any goods that supplying countries can ship.

In order to sustain United States trade with South America, the official Export and Import Bank of Washington is to grant short-term banking credits so as to overcome difficulties of financing current trade, caused by war-time delays in delivering American manufacturing goods. Further, so far as the North American defence programme allows, priorities are being given for the delivery of essential manufactures to South America. Although Japan's trade with South America has not been large, the outbreak of hostilities in the Far East is expected to aggravate still further the shortage of shipping in the Western Hemisphere, thereby prejudicing both import and export trade, the most serious danger being the effect upon supplies of such essential goods as tinplate, coal and oil.

The recent annual reports of the British-owned railways in Argentina confirm the continued unfavourable working conditions of the lines, with the consequent restricted demand for engineering equipment. Meanwhile, however, road competition increases, the Buenos Aires Transport Corporation, for instance, having completed arrangements for the purchase of some further 300 omnibuses, etc., for use in that city. The shortage of fuel continues acute in Argentina, although it is to be noted that the national output of petroleum during the first nine months of 1941 reached the record total of 2,572,000 cub. m., principally from the State oilfields. A Bill presented in Argentina proposes the nationalisation of all commercial air lines and activities, for which purpose an appropriation of 12,000,000 pesos would be required. The Argentine Government has approved an important project for enlarging and improving the Port of Quequén, at a cost of some 2,000,000*l.* sterling, to be completed by 1949. The plan includes the erection of new warehouses, wharves, railways and roads, and the necessary dredging.

Accelerated by difficulties in obtaining imported heavy goods, the industrial development of Brazil is proceeding rapidly. Attention is being given to the improvement of transport facilities so that national industries may make the fullest possible use of the country's wealth of raw materials, which include large deposits of iron ore and coal. Discussions are proceeding with the United States authorities with a view to obtaining priority for Brazil's imports, from the United States, of railway locomotives and wagons, tinplate for the national packing industries, and equipment for the electrification of the Sorocabana Railway. In fact, it is reported that it has already been decided to give priority to Brazilian orders for railway electrification material, in view of the present shortage of coal for Brazilian railways and the necessity for arranging transport from the interior of Brazil for strategic minerals destined for shipment to the United States.

The total value of Brazil's annual industrial output increased from 20,013,000 contos in 1938 to 25,154,000 contos in 1940. (One conto = 12*l.* 10*s.*) Exports of iron and steel in 1940 totalled 31,098 tons, against only 5,766 tons in 1938. The production of cement is now being retarded due to the shortage of crude oil used by the works. In this connection, the total supply of combustible oil in Rio de Janeiro and São Paulo is said at present to be only about 68 per cent. of normal. A recent decree created a National Fuel and Lubricants Board empowered to co-ordinate the general policy of the Brazilian Government for the production and distribution of combustibles and lubricants.

The progress of technical engineering in Chile is indicated by the successful righting of the floating dock in Valparaiso, which was capsized by a violent storm in May, 1940. It is hoped that the dock will soon be again in condition to render service to shipping. By the recent authorisation to the Argentine State Railways to complete the projected line between Rosario de Lerma and Socampa, a new railway link between Argentina and Chile will be forged, and the logical extension would be to the Pacific coast port of Antofagasta.

LABOUR NOTES.

DURING November, the home-branch membership of the Amalgamated Engineering Union increased from 532,568 to 545,670, and the Colonial-branch membership from 52,172 to 54,753. The number of members in receipt of sick benefit increased from 4,915 to 5,150, and the number of superannuated members from 13,300 to 13,316. The number of members in receipt of donation benefit decreased from 151 to 124, and the total number of unemployed members from 1,231 to 1,172.

Mr. Fred. A. Smith has been nominated for re-election as general secretary of the Amalgamated Engineering Union. Other candidates who have accepted nomination are:—Mr. R. Glastonbury, of Benoni, South Africa; Mr. C. Hoyle, of Brixton; and Mr. W. H. Price, of Sunderland. The last day for voting is February 9, and the result of the home vote must reach the General Office not later than February 11. Eight candidates have accepted nomination for the position of assistant general secretary (Trade Union Department), including Mr. B. Gardner, the present occupant of the office.

Mr. Tanner, the President of the Amalgamated Engineering Union, reports in the December issue of the organisation's *Journal*, that the Ministry of Labour and National Service was met by the President, executive council and general secretary on November 11, when phases of the Essential Work (General Provisions) Order (No. 302), and the Amending Order (No. 1051) were discussed. On behalf of the union it was pointed out that experience had shown that hardship, anomalies and lack of equity resulted from the application and operation of the Orders. A number of cases were cited in support of the union's contentions. "The Minister," Mr. Tanner says, "dealt with specific cases and promised to give consideration to our representatives on the more general aspects. An application has been made to him for an adaptation of the Order so as to bring it into line with the practice applicable to the shipbuilding and ship-repairing industry."

Under an agreement to which the Flour Milling Employers' Federation and the Amalgamated Engineering Union are parties, the wages of mechanics employed in the industry covered by the National Agreement of February 20, 1940, have been increased by 4*s.* 6*d.* a week. The increase has operated as "from the first full pay period subsequent to November 20."

The whole of the editorial notes in the December issue of the Amalgamated Engineering Union's *Journal* deal with the wages question, and as they, obviously, were written before the issue of the National Arbitration Board's award, they are necessarily a little lacking in point. On the general question, however, Mr. Smith—who as general secretary of the union is Editor of the *Journal*—claims that in pressing the demand for an increase of 4*d.* an hour—on basic rates, the union sought "a reasonable solution of the wage question." "The union," he continues, "yields to none in its resolve to assist in winning the war. We have done, and are doing, all that lies in our power to speed up, and keep up, the production of arms and munitions. The great body of the workers we represent are doing essential war work. . . . Their service is given unstintingly. Through their trade-union organisation they have co-operated in every possible way to increase production. They have made sacrifices, individually and collectively, to enable the munitions trades to be put upon a war footing and to meet the demand for maximum and sustained effort in all branches of the industry."

The union, Mr. Smith goes on to say, has "followed the constitutional course in putting forward its case for an increase. It has done nothing to embarrass either the Government or the employers, or to impair the spirit which prevails in the workshop and shipyards. We may, as a union, regret, and, in fact, do regret, that the Engineering and Allied Employers' National Federation took up an attitude which necessitated the reference to the National Arbitration Tribunal. This is a departure from established practice in the engineering industry. We should have preferred to see the industry settle its own problems by the use of its own machinery of collective bargaining."

The increase of 5*s.* a week which has been awarded by the National Arbitration Tribunal, is, of course, on the national bonus, and not, as the union desired, on basic rates. Mr. Smith submits that the claim for the raising of the basic rates was justified "up to the hilt." It was not answered, he says, by the employers' contentions, concerning the inflationary effect of wage increases. The union denied that the raising of the industry's basic rates would have such an effect any more than the recent raising of farm workers' wages by 12*s.* a week.

The International Labour Review states that new regulations have been issued in the form of a Canadian Order in Council, supplementing previous Orders extending the provisions of the Industrial Disputes Investigation Act to disputes between employers and employees, engaged in the production of munitions of war and supplies and in the execution of defence projects. Under that Act no strike is authorised until the dispute has been submitted to a board of conciliation and investigation, and the parties have been given an opportunity to accept or reject the board's decision.

The regulations lay down that once the findings of a board have been reported to the Minister of Labour and certified copies of the report have been delivered to the parties to the dispute, no strike shall be lawful unless the employees first notify the Minister of Labour of their desire to strike or to take a strike vote. If the Minister is of the opinion that a cessation of work would interfere with the efficient prosecution of the war, he may direct that a strike vote be taken under the supervision of the Department of Labour, subject to such conditions, restrictions or stipulations as he may determine. All employees who, in the opinion of the Minister, are affected by the dispute, or whose employment might be affected by the proposed strike, shall be entitled to vote. The voting must take place within five days from the date upon which the Minister received notice of the employees' desire to strike. It is expressly stipulated that unless a majority of the votes are cast in favour of a strike, it shall be unlawful for any employee to go on strike.

A fine not exceeding 500 dols. or imprisonment for a time not exceeding 12 months, or both penalties, may be imposed by the courts on any employee who goes on strike contrary to the new provisions, and on any person who fails to comply with the new regulations, or any Order issued thereunder by the Minister of Labour. This penalty may likewise be imposed on anyone who, in any manner, incites, encourages, or aids any employee to go, or continue, on strike, or incites, encourages, or aids any person to contravene the new regulations or any Order issued thereunder by the Minister of Labour.

As the result of a strike of coal distributive workers in South Africa, 366 Africans were prosecuted for failure to obey lawful orders, and a fine of 1*l.* with the alternative of 10 days' imprisonment was imposed in each case. The sentences were suspended, however, while the men continued to be of good behaviour. Later, a deputation representing the South African Institute of Race Relations and The Friends of Africa suggested to the Departments of Labour, Native Affairs, and Justice that, in future, the criminal law should not be invoked against African workers who strike except in circumstances where the law would also be invoked against other workers. It was urged that, in any case, no police action should be taken before an official of the Department of Labour had made a full investigation.

Subsequently, the Secretary for Justice issued a circular to the police authorities in the following terms:—"Recent disputes between employers and Native employees engaged in industrial undertakings have indicated that there is a possibility of an employer, on occasion, seeking to take advantage of the provisions of the criminal law to the detriment of Native workmen. In cases therefore, where complaints are made to the Police that Natives engaged in industries have refused to go to work—in other words, have gone on strike—the Minister directs that no steps, by way of arrest or prosecution, are to be taken against such Native employees for such refusal to work until the matter has been reported to the local representatives of both the Native Affairs Department and the Department of Labour in order to give such representatives an opportunity of settling the dispute if possible without invoking the criminal law."

The system of labour service for young persons, which had previously been organised in the Netherlands on a voluntary basis was made compulsory by an Order of the German Commissioner dated May 26. According to section 7, any Netherlands national, irrespective of sex, between the ages of 18 and 25 years who lives in the territory of the Netherlands must complete a period of compulsory labour service lasting six months. The object in view is stated to be "to imbue young people with the spirit of work in general and to stimulate respect for manual work in particular."

DIAMONDS AND OTHER GEM STONES FOR INSTRUMENTS AND MEASURING APPLIANCES.

IN a lecture to the British Horological Institute, delivered on June 11, 1941, and entitled "Jewels in Time-Pieces and Instruments," Mr. Paul Grodzinski dealt with the use of gem stones for pivots and bearing points in watches and other instruments, and for scratching and indentation purposes in hardness-testing and other applications. The account of the lecture which follows has been restricted, in the main, to the sections bearing more directly on engineering practice.

In the first part of his lecture, Mr. Grodzinski dealt with the special properties of diamonds and other gem stones which distinguish them from metals. They exhibit extreme hardness, with consequent high resistance to scratching and abrasion; low friction coefficients, owing to their single-crystal structure; and resistance to corrosion and oxidation. The diamond is the hardest mineral known, although it exhibits a range of hardness which has not yet been fully explored. This point should be kept in mind when selecting stones. Owing to difficulty in machining, diamonds are in general, used only as wearing-plate end stones in highly accurate chronometers and as bearing or scratching points in hardness-measuring appliances. For other industrial applications, minerals of lower hardness are used, as indicated by the crosses in Table I.

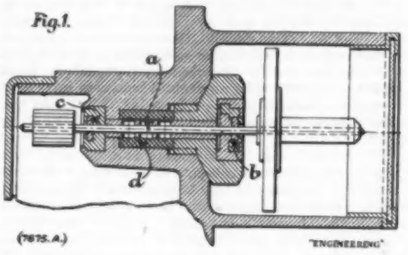
TABLE I.—*Industrial Applications of Diamonds and Other Minerals.*

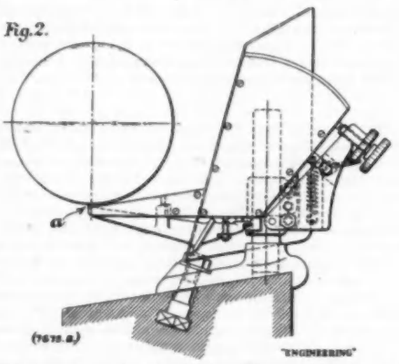
Application.	Diamond	Corundum.		Quartz.	Garnet.
		Natural.	Synthetic.		
As bearings—					
Knife edge ..		+	+	+	
Cylindrical ..		+	+	+	+
End stones ..	+	+	+		+
Cup (pivot)	+	+	+		
As wear resisting materials					
Plates ..	+				
Hemispheres	+				
Nozzles for oil burners ..	+				
Mortars and pestles ..				+	+
Gramophone records					
Cutting points	+	+	+		
Reproducing points ..	+	+	+		
In scientific instruments—					
Hardness testers ..	+				
Scratching records	+	+			
Optical lenses	+			+	

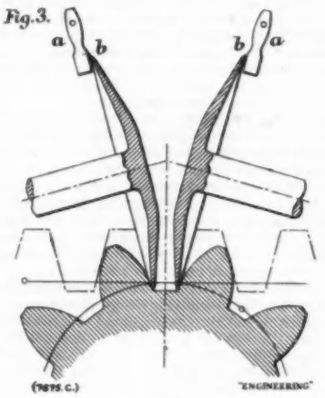
Precious stones other than diamonds vary considerably in their degree of hardness. Australian sapphires are the most resilient and yellow sapphires the hardest. Sapphires are harder than rubies and Ceylon sapphires harder than Kashmir sapphires. Synthetic rubies were first produced about 30 years ago, and about 90 per cent. of jewel bearings in watches are now synthetic. For knife-edge bearings, chemical mortars and pestles, and similar applications, such materials as agate, especially chalcedony and carnelian, have hitherto been used. They are found in larger pieces than other suitable natural stones. Synthetic sapphires may perhaps be used in the future. The diamond has seldom been used for bearings, on account of its high cost and the difficulties involved in cutting and polishing. The manufacture of precise forms and sizes for interchangeable production is very difficult. Sintered materials of great hardness have recently been produced which, for some purposes, may take the place of natural and synthetic gem stones. They include sintered tungsten, titanium, or tantalum carbide and boron carbide. In spite, however, of attempts to improve the microstructure of these materials, they still consist of multiple crystals in a softer matrix, whereas gem stones have a more or less single-crystal structure.

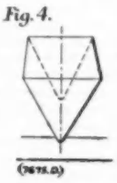
Bearings and Pivots.—When jewels are used for bearings, the spindle diameter and hole are kept to a minimum, in order to reduce friction. Cylindrical bearings of sapphire or ruby are now produced in quantity by special machinery and are available for general application. Two such bearings are utilised in the Warren synchronous clock motor which is illustrated in Fig. 1, on this page. The rotor spindle *a*, which revolves at 3,000 r.p.m., is carried by two cylindrical jewel bearings, one *b* at the rotor end, and the other *c* at the gear end. Between them is an oil-impregnated cotton-wool pad *d*, separated from the spindle by a perforated sleeve. In a wrist-watch, out of 26 different bearings, 11 are usually of the jewel type and comprise 13 single stones. Some watches have as many as 21 rubies. Pivot bearings consist of a plain drilled jewel against which runs a shoulder on the spindle, or, alternatively, an end bearing jewel is provided in addition. This is a better arrangement, the radial and axial thrusts being taken by separate jewels. The jewels have cavities for lubricating oil.

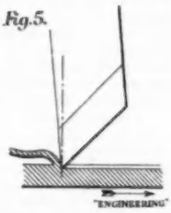
INDUSTRIAL USES OF JEWELS.











Conical pivot bearings are preferable in wattmeters, compasses and other instruments, as they give the minimum friction. The position-control of the spindle, however, is not very accurate. When used in a horizontal position, the axial backlash results in a small downward displacement of the spindle and an increased friction torque. With a vertical arrangement, the bearing and spindle are coaxial and the friction drag is very slight. Steel pivots are common, but as early as 1840 experiments were made in the use of other alloys. Kinnard and Goss found that steel points of 0·0185 in. radius broke easily, but cobalt-tungsten alloy pivots of the same size were satisfactory. Cobalt-tungsten pivots are softer than steel pivots and tend to flatten slightly, reducing the unit pressure on the jewel without measurably increasing the friction. The ratio of the radius of the pivot to the radius of the cup should be approximately 7 to 10. Corrosion is avoided if the point and cup are made of different minerals; jewel pivots in jewel cups have been used for some years. The cup may be of sapphire and the point of agate; or the cup of diamond and the point of sapphire. An application of this kind is found in the 1917 Admiralty standard compass, which has a sapphire cup and an agate pivot point. Compass jewels are highly stressed owing to the small movement of the needle and the shock loads, particularly in the case of aircraft instruments. A recent British Standard Specification, No. 904-1940, covers cylindrical pivot bearings, conical pivot bearings, end stones and three designs for compass stones. It is not intended for application to watches or integrating meters.

In contradistinction to circular bearings, knife-edge bearings are subjected only to a limited swinging motion, with little friction. The knife-edge and seat, however, may be subjected to considerable shock. Such bearings, in general, are used only in scales and fine measuring instruments. For scales, agate is frequently used, although it has only a hardness of 6 on Mohs' scale. It can easily be obtained in the requisite sizes, and, if necessary, ground and polished in position.

Wear-Resisting Plates.—The first use of jewels as wear-resisting plates seems to have been for pallets in watch and clock escapements. The earliest application was probably by the famous British clockmaker, Mudge, in about 1754. The use of jewel bearings in watches is older, the first record being found in the British patent of Facio and Debaufré, of 1704. Compass jewels seem to have been first used by Servington Savery, of Chilston, in 1705, but did not come into common use until the second half of the Eighteenth Century; even then glass plates were frequently used.

Jewels are used for wear-resisting surfaces in various measuring appliances, employed, for example, in connection with grinding operations. Diamonds, or more rarely, sapphires or sintered tungsten carbide, are used for the measuring points which come into contact with the revolving work. The pressure must be kept low and must be related to the radius of curvature of the point, in order to avoid scratching the work. H. Törnehohm* recently stated that a spherical diamond point of 2·5 mm. radius, under a pressure of 1 kg., would make an impression 0·001 mm. deep. This error would, of course, be doubled if a diameter were measured between two points of contact. The Fortuna-Werke external measuring device is shown in Fig. 2, in which the circle on the left represents the revolving workpiece, the measuring point being at *a*. This consists of a 0·1 to 0·15-carat size diamond mounted in a holder, which is carried by a pivoted arm secured to the bed of the machine. Measurements can be made while grinding is in progress.

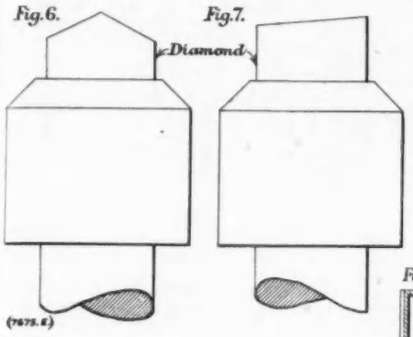
An alternative method of sizing cylindrical parts during grinding employs a three-point contact. The points are usually diamonds of spherical form about 2 mm. in diameter, so that the surface of contact is very small. In the British Pratt grinding gauge of Messrs. Engineering Products, Limited, diamonds mounted at the tips of setting screws are arranged one below the work and the other in front, 90 deg. from the first. A third diamond, on top of the work, is carried by the stem of a dial indicator. The diamond points are flat or conical. The Maag gear-grinding machine is equipped with a contact device which shows the wear of the grinding wheels, indicating when they should be trued up. A diagrammatic sketch of this arrangement is given in Fig. 3. Flat diamonds *b b* are carried by the levers *a a* in positions opposite the cutting edges of the cup wheels. Normally a space of about 1 mm. is left between the diamonds and the wheel, but at intervals of about 5 seconds the levers are tilted to bring the diamonds into contact with the wheels under very slight spring pressure. The wear of the wheels measured in this way is indicated on a gauge.

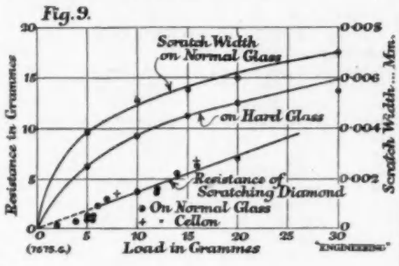
Contact diamonds are applied, not only for automatic sizing arrangements of this type, but also for precision gauges in which frequent measurements are made on the same point. An example is furnished by pitch-diameter gauges for threads. In such cases the diamonds are formed with a point having an included angle of 55 deg. to 60 deg., corresponding to the thread. Where the precision demanded is not so high, such materials as sintered carbide may be used instead of diamonds; their wear-resisting properties are higher than that of hardened steel.

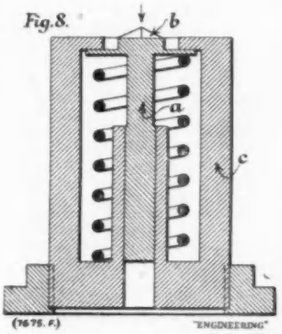
Owing to the low price of crude oil in the United

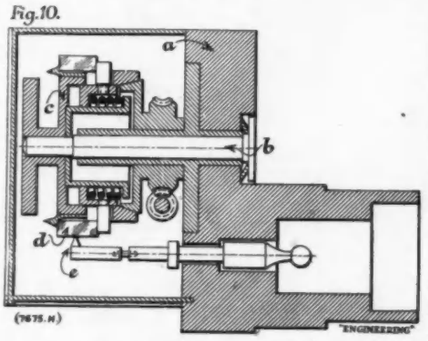
* *Schweizer Archiv. f. angew. Wissenshaft und Technik*, Nov., 1939.

INDUSTRIAL USES OF JEWELS.









States, domestic central-heating plants fitted with automatic oil burners have come into extensive use. The abrasive action of the oil spray is found to enlarge the fine holes in the nozzles in a relatively short time and diamond nozzles, on the lines of the diamond dies used for wiredrawing, have been recently introduced. The results have been very satisfactory and show considerable saving. Although the initial cost of the nozzles is high, they have a long life and give a uniform rate of oil consumption. With metal nozzles, owing to wear, the oil consumption has a tendency to increase. It is worth considering whether diamond nozzles might usefully be employed for Diesel-engine fuel injection, water sprays and sand blasting.

Gramophone Cutting and Playing Needles.—As is well known, ordinary steel needles used with gramophone records wear so quickly that they can only be used once. Various alternatives are in use, but for cutting, when manufacturing records, sapphire or diamond needles are employed. The shape of the cutting point has to be related to the material being cut. A tool with a negative rake angle, as shown in Figs. 4 and 5, opposite, is often used but it has been found that a tool without any rake gives the most satisfactory results. When sapphire is used it is possible to make needles accurately to form, but with diamonds, owing to the difficulties of cutting and polishing, the maintenance of a fixed cutting angle is not easy. This disadvantage of diamond needles has been met by means of gauges supplied by the manufacturers, which ensure that the needle is set so as to present the correct cutting angle to the work. Such appliances as dictating machines are furnished with diamond needles polished to definite angles. Figs. 6 and 7 show the type of diamond point which has been used successfully on a Continental dictating machine, using gelatine discs. A new process for the production of gramophone records has recently been introduced in America. It avoids the use of wax-plates from which shellac masters are made. A thin aluminium disc is cut with a diamond point and, from this, a negative is made from a thermo-setting resin. This negative is then used as a master for the production of discs for general use.

Hardness Testing.—The testing of hardness by means of a sharp crystal point was one of the earliest scientific applications of minerals. The ancient Indians and Greeks rubbed two stones together to ascertain, by scratch or sound, which was the harder, the method later being extended to the use of testing points and needles for the identification of minerals. A further step was the evolution of the scratch hardness tester. This type of instrument, which was invented by Seeberg in 1830, and later improved by Martens, invariably employed diamond points. It ultimately developed into modern hardness testers which employed microscopic examination to observe the finest scratches and indentations. The first micro-hardness tester was introduced by V. Poeschl, in 1909, and was followed by the instruments of Bierbaum and Zeiss. The scratch, in the case of the Bierbaum instrument, was made by the corner of a diamond cube; Zeiss employed a chisel point or cone with an included angle of 120 deg. In the earlier work of Martens the angle was 90 deg.

The scratching method is only suitable for laboratory use. The hardness value is usually expressed in terms of the load necessary to produce a scratch of standard width, generally 0·01 mm. The hardness has to be determined by graphic interpolation. The procedure has been practically superseded by the indentation process in which an impression is made under a definite load. The size of the impression is inversely proportional to the hardness. The first successful instrument of this class was evolved by Brinell, who used hardened steel balls as indenters. Diamonds were later introduced, various forms being employed, such as hemispheres, cones with or without a rounded point, pyramids, and flat-pointed square or rectangular forms. The diamond cone, as used on the Rockwell and Alpha machines, is very largely employed. Diamond pyramids have the advantage that the result is independent of the applied load. In recent years micro-hardness testers employing the indentation method have been developed, the latest being the Hanemann* instrument and the "sensitive" diamond point of Fr. Knoop. The first instrument with which microscopic measurement of the indentation was used was that developed by Lips; it is shown in Fig. 8. The stem *a*, furnished with a diamond point *b*, is mounted inside a cylindrical casing *c*. The internal spring normally holds the diamond above the upper surface of the casing, but if the end of the apparatus is brought into contact with the specimen to be tested, sufficient pressure being applied to bring the surface flat down on to the work, an indentation is made under a load of 20 grammes. Professor Hanemann and his collaborators finding this, and similar instruments, difficult to handle, particularly in centring the indentation under the microscope, devised an arrangement in which the mechanical and optical components are combined in a single instrument.

The Hanemann micro-hardness tester has a front lens of glass in which the diamond, 0·8 mm. in diameter, is mounted. To avoid optical distortion, a lens system with homogeneous immersion is used. The possibility of using a diamond lens has been investigated, but no immersion fluid suitable for the high refractive index of the diamond is available. Other gem stones, approaching the diamond in hardness, could not be used, and the combined glass and diamond arrangement was finally adopted. The instrument incorporates arrangements for measuring the applied load. The Knoop "sensitive" pyramidal diamond point* produces an indentation of oblong shape. It is particularly useful when indentations are used for measuring wear. In this application, after initial measurement of the indentation, the part is put into service. After a specified time, the indentation is measured again, the reduction in area giving a factor from which the wear can be determined.

Scratching Diamonds.—Scratching by means of a diamond point may be used in measuring and recording instruments, the records produced being examined by means of a microscope or projection apparatus. The diamond point has great durability and produces finer and more uniform grooves than can be obtained in any other way. The relations between load and scratch width and scratch resistance are shown in Fig. 9. The records are magnified from 100 to 500 diameters for reading the results. The accuracy of the method is dependent upon the precision with which the curves can be read. A recording instrument† employing the method is illustrated in Fig. 10. The housing *a* carries a fixed spindle *b* on which the drum *c* is slowly rotated by a worm gear. The cylinder *d* of glass, or other suitable material, on which the record is made, is carried by the drum *c*. The whole instrument is very small, the drum being only about 1 in. in diameter. The scratching diamond *e* is carried at the end of a light tube, which is given an approximately parallel motion by a double-link arrangement. The outer end of the tube is connected to the apparatus, the movement of which is to be recorded. A separate diamond is provided for tracing the base line. Both diamonds can be lifted out of contact when the glass cylinder is being changed; the pressure they exert is controlled and adjusted by a leaf spring. The external dimensions of the complete instrument are $1\frac{7}{16}$ in. by $1\frac{7}{16}$ in. by $1\frac{3}{4}$ in.; it weighs $4\frac{1}{4}$ oz. The instrument can be applied for measuring tension, pressure, torque and acceleration, and owing to its very low inertia has great accuracy. For aero-engine work, a special form has been devised with which revolutions over a period of 200 hours can be recorded on a helically-rotating glass cylinder.

Surface-Roughness Testers.—While on the instrument just described, it is essential that a scratch should be made, although so fine that it can only be seen under a high magnification, in surface-roughness testers a scratch should be avoided,‡ otherwise the recording point would not accurately follow the surface contour. A definite standard has not yet been established in the measurement of the surface roughness of machined parts. The design of the tracer point, although a minor part of the whole problem, does not seem to have been given the attention it deserves. The radius of the point, even if very small, affects the curve reproduced. In the case of the Brush Surface Analyser,§ a sapphire point with a radius of only 0·0005 in. is used, but it is necessary to consider how long such a fine point will last before wear occurs. With diamonds it might be possible to produce a genuine sharp edge, but this would cause a slight scratch even under the minimum load. A proper balance has to be obtained between the deformation of the curve caused by a radius and the scoring caused by a sharp point. It is not known if this has been taken into account in practice, but it is not dealt with in the numerous publications on the subject.

Optical Use.—The high refractive index of the diamond, far higher than that of any other known liquid or solid substance, seems to recommend it for high magnifications and particularly for lenses of small size. Obviously a diamond lens requires a smaller curvature than a glass lens of the same power. A special advantage of such lenses is that they are not easily affected by dust and dirt, and need not be so carefully cleaned as normal lenses. As only diamonds of the clearest water could be used, the cost would be high, and in many cases prohibitive. The grinding of such lenses, however, would not seem to present great difficulties. I. Pike and B. W. Anderson, of the Mineralogical Institute have designed a refractometer in which a diamond is utilised as the material for a prism. The size of the stone before cutting was 6·6 carats, the finished size being 2·5 carats. The refractive index is between 2·41 and 2·45.

PERUVIAN MICA.—A report from Peru states that a trial cargo of mica has recently been shipped from that country to the United States. Hitherto, the output of mica has not been important, but it is stated that the production could be considerably augmented if satisfactory markets were found for the material.

* Hanemann and Bernhardt, *Zeits. f. Metallkunde*, vol. 32, page 35 (1940).

* U.S.A. Patent 2,091,995. See ENGINEERING, vol. 151, page 87 (1941).

† *Archiv. Technisches Messen*, Munich, November and December, 1938.

‡ Boston and Gilbert, *Mechanical Engineering*, November, 1940, page 785; also *Industrial Diamond Review*, No. 8, page 50, 1941.

§ See ENGINEERING, vol. 151, page 356 (1941).

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

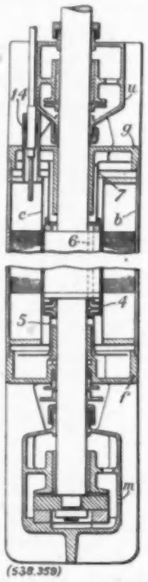
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

538,359. Submersible Motor. James Beresford and Son, Limited, of Birmingham, and R. L. Gold, of Birmingham. (2 *Figs.*) October 27, 1939.—The motor is designed so that the rotor bearings are protected against the bad effects of heat. The stator windings are enclosed by the casing *b* and a tubular lining *c*. The housings for the upper and lower bearings for the rotor shaft are separate from the ends of the stator casing covers *f*, *g*, and are connected to the latter by ribs constructed to provide ample heat-insulating spaces. The lower housing *m* contains a journal bearing and an end-thrust bearing, the mouth of the housing being protected by a centrifugal thrower on the shaft. Before installing the motor



(538,359)

the housing is filled with oil. The housing is ribbed to assist in heat dissipation. The upper housing *u* encloses a journal bearing, and the apertures at each end of it are protected against ingress of grit by throwers. Anti-vibration steadies for the rotor shaft are combined with the end covers *f*, *g*. When it is likely that considerable heating will occur the shaft carries an impeller 4, and adjacent to it is mounted a stationary guide 5 supported by ribs in the end cover *f* which form flow and return passages. Passages 6 are formed in the rotor which register with another stationary guide 7 in the end cover *g*. The packing glands through which the cables enter the stator casings are arranged in tubular extensions 14, in order to reduce the risk of undue temperature rise in these parts of the cables. The machine can operate at high temperatures without detriment to the bearings. (*Accepted July* 31, 1941.)

FURNACE APPARATUS.

539,046. Soaking-Pit Cover. Stein and Atkinson, Limited, of London, and J. S. Atkinson, of London. (13 *Figs.*) April 20, 1940.—The invention is an arrangement by which the cover of a soaking pit is raised or lowered in a straight vertical path, and traversed horizontally by the same mechanism. The cover 2 is suspended through its girder frame structure 5, from four short lifting shafts 6, two at the front corners and two near the rear corners of the cover. Each lifting shaft 6 is mounted in one end of a cranked lever 8, 9, each pair of levers pivoting on one of the two axles 10 of a traversing carriage on which are keyed flanged wheels. The arms 9 of the cranked levers at each side of the carriage are connected together by the side girders, and near the rear axle a crosshead between the side girders connects the carriage to a drawbar 14. The cranked levers at the front of the carriage are each integral with a curved forward arm 20, which carries a roller 21. The two rollers 21 engage the tracks, which terminate at the front end in two downwardly curved grooves 23. The carriage is moved backwards and forwards along the tracks by an electric motor which drives a pinion engaged with a rack on the underside of the drawbar 14. In operation, let it be assumed that the pit is open with the cover 2

Fig. 1.

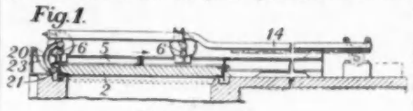
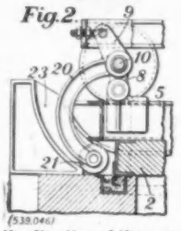


Fig. 2.



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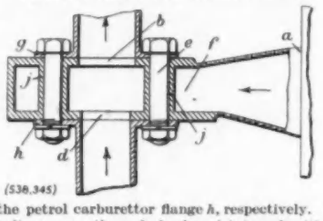
moved away in the direction of the arrow. The carriage with the cover suspended from it is traversed forward on the tracks, the rollers 21 at the ends of the curved arms 20 engaging the tracks to hold the cranked levers in a fixed angular position. When the cover comes into position over the pit the rollers 21 have reached the curved grooves 23. The cranked levers then turn about their pivots on the front axle of the carriage, thereby lowering the cover towards the pit. The grooves are shaped so that the carriage moves forward enough to compensate for the rearward movement of the ends of the arms 8, so that the cover moves in a straight vertical path to the closing position. The motor is cut out as the cover comes into position over the pit and the rollers 21 enter the grooves 23. The cover is supported directly by the carriage so that the driving gear is relieved of load. When the cover is to be removed, the first effect of a pull on the drawbar 14 is to raise the cover in a vertical straight line until the rollers 21 at the ends of the curved arms 20 leave the grooves 23, after which the carriage is traversed to move the cover away from the pit. (*Accepted August* 26, 1941.)

MOTOR VEHICLES.

538,345. Alternative Fuel Supply Connection. Parkinson and Cowan (Gas Meters), Limited, of London, and K. R. Green, of London. (6 *Figs.*) January 23, 1940.—The invention is a device for connecting alternative fuel supplies to internal-combustion engines, and is particularly designed to suit car engines where there is little room available for the more usual forms of T-connections. It also aims at reducing friction of the gas flow. A two-inch tube *a* of circular cross-section is connected to a flange on a throttle in a gas producer circuit. The tube is flattened at *f* to a rectangular cross section, the two large opposite faces having openings *b d* and being faced to seat against the inlet manifold flange



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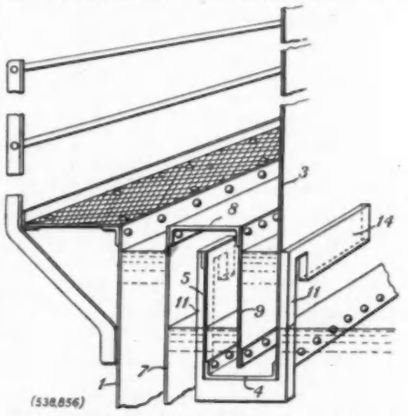
g and the petrol carburettor flange *h*, respectively. The flange-bolts *e* pass through bushes *j* integral with the casting to prevent deformation of the flattened faces of the tube on tightening up. The carburettor is separated from the inlet manifold flange only by the narrower dimension of the flattened end of the tube. (*Accepted July* 30, 1941.)

MISCELLANEOUS.

538,856. Multiple-Lift Gasholders. Newton Chambers and Company, Limited, of Sheffield, and M. A. Thompson, of Sheffield. (1 *Fig.*) January 10, 1941.—The invention is an arrangement for preventing the pressure of gas trapped under a dip from rising above that in the gasholder bell, and so producing "blowing" of the gas through the water seal between adjacent lifts. The tank 1 contains water. Attached to the wall 3 of the lift is the cup channel 4 and cup skirting plate 5 forming the cup while the wall 7 of the next lift carries the dip channel 8 and the dip skirting plate 9. The pressure equali-ing duct is an open-ended U-tube of rectangular cross section and has two vertical limbs 11 connected by a horizontal portion at the bottom which extends under the cup channel 4 while the limbs 11 extend up



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on the inside of the lift 3 and the outside of the cup skirting plate 5. The upper ends of the limbs 11 are turned over so that the open ends are pointing downwards at the same level. The lower part of the duct is of larger cross section than the limbs 11 to provide a small reservoir for the accumulation of any condensate. The bent over end of the U-tube inside the gasholder bell is enlarged at 14 to form a compression chamber. The ducts connect the interior of the gasholder below in the dip space when the bottom of the cup is below the tank water level, thus preventing the gas pressure in the dip from increasing higher than the main gasholder pressure, and therefore preventing the "blowing" of gas under the dip skirting plate during uncupping, and the overflow of water from the cup over the dip during the process of cupping. (*Accepted August* 19, 1941.)

END OF THE ONE HUNDRED AND FIFTY-SECOND VOLUME.